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ORIGINAL ARTICLES.

I.—On some Samples of Rock from Borings at Sangregrande, Trinidad.—Part I.

By R. J. Lechmere Guppy.

(FOLDING PLATE VII.)

I HAVE been favoured by P. N. H. Jones, Esq., engineer of the Waterworks, with specimens from a boring at Sangregrande undertaken by the Government of Trinidad with a view to ascertain the extent and position of the Tertiary coal-seams of that district and other facts. The specimens consist of a dark-coloured (blackish) sand-rock, finely (but slightly irregularly) laminated, the lamination being at an angle of about 50° from the horizontal. The samples came from 150, 250, 400, 500, and 600 feet deep below the surface. I examined each one separately, but as the differences between them, whether as regards mineral constitution or organic contents, are only slight, and in fact two portions from the same depth show often as much difference as samples from different depths, I shall describe the whole together. These specimens are from boring No. 3, Plate VII.

The rock is of a blackish or dark-grey colour, and is principally composed of very fine sand with particles of mica. When washed and passed through fine muslin only about $\frac{1}{100}$ part remains. Calcareous matter is under 10 per cent. in quantity, and exists almost entirely as shells of Foraminifera and Mollusca. Crustacea and echinoderm remains also occur, and there are numerous Polyzoa, a few Ostracoda, and scales, teeth, and ear-bones of fishes. I could not detect coccoliths or calcaroma, but the nature of the material is unfavourable for their detection. The material of this rock is not of any economic value, but it is interesting as throwing light upon geological questions and upon the conditions which prevailed at the time of its deposition. The neighbourhood of land is indicated by the quantity of clastic material, but the fineness of the grains and the tenuity of the laminæ of deposition show that it was at some distance off. Data exist for an approximate estimate of the position of such land, and the elementary facts are indicated in my papers in

the Proceedings of the Victoria Institute, Trinidad, 1902, and the Journal of the Geological Society of London, 1892.

With one exception the rock appears to be of the same quality and consistence throughout. At 500 feet occurs a harder bed composed of similar material to the other beds, but indurated and not liable, as the other beds are, to disintegration by water. This harder bed contains only traces of calcareous matter, and much fewer organic remains than the others.

I have no particulars of the material found at intermediate depths, but presuming that it is uniform or nearly uniform throughout it would appear that we have here a thickness of more than 500 feet in depth of very fine sedimentary material, probably deposited in a sea somewhere about 20 to 50 fathoms deep. It might even have been more, but to ascertain this other circumstances not at present known would have to be taken into account. The deposition of so extensive a stratum of such material implies a long period of time during which the conditions of the area on which deposition was taking place remained generally the same.

The molluscan and other organic remains exist entire within the matrix, but being for the most part in the state of powder they cannot be extracted. The Foraminifera and a very few Mollusca and Ostracoda alone are of a sufficiently compact consistency to stand extraction by washing, which is the only mode of operation practicable, as any attempt by more forcible means results in the complete disintegration of the fossils.

Doubtless also here, as in the Naparima and Pointapier beds, many Foraminifera appear as fragments only, such as *Rhabdammina*, *Haliphysema*, *Dendrophya*, etc. But leaving apart such organisms as these, there will be, if occasion serves in the future, an enormous extension of this list of fossils.

MOLLUSCA.

Balantium.	*Pleurotoma.*
Bulla.	*Nucula.*
Dolium.	,,
Fusus.	*Pecten.*

The only specimens extracted were a *Pecten* and a *Nucula* (single valves). One valve of a *Pecten* is ornamented with radiating elongate-elliptical blotches of purplish-brown colour, showing how persistent the original colouring must have been to have been preserved in such decolorizing material as that of which these beds are composed.

POLYZOA.

The only generically identifiable one is *Cupularia*, but others seem to be *Membranipora*, etc.

OSTRACODA.

Bairdia woodwardiana, Brady; *Cytherella polita*, Brady. There is also a prawn-like crustacean over an inch long.

FORAMINIFERA.[1]

I deal in greater detail with the fossils of this group, as they present determinable specimens belonging to known forms.

Clavulina (Haplostiche) Soldanii, Parker & Jones. (Pl. IX, Fig. 1.)

This species is numerous at all depths, but especially at 150 and 250 feet. It does not occur in the Naparima (oceanic) beds, but I have examples from the *Ditrupa*-bed of Pointapier, which I originally identified as *Clavulina cylindrica*. The length of the longest example from the Sangregrande boring is 3 mm., its breadth being 1 mm.; the stoutest example is 2·5 mm. long by 1·5 mm. in diameter. There are many smaller examples of varying forms.

Reophax scorpiurus, Montf. (Pl. IX, Fig. 2.)

This is not quite as common as *H. (Cl.) Soldanii*, but is nevertheless fairly abundant in some samples. It has not hitherto been met with by me in any of the other Microzoic rocks of Trinidad. It is usually about 2 mm. in length.

Amodiscus incertus, Orb.

A single specimen somewhat like that figured in Ann. Nat. Hist., vol. iv (1869), pl. xiii, figs. *3a*, *b*.

Cyclamina cancellata, Brady, var. deformis, nov. (Pl. IX, Fig. 3.)

Most specimens of this form are distorted by a sudden change in the axis of growth of the last whorl, whereby the shell acquires a sort of humpbacked appearance. It is often very thin, seldom indeed as thick as the forms found abundantly in some of the Naparima oceanic beds. It is one of the largest Foraminifera in the Sangregrande boring, being mostly 3 mm. in diameter, and occurs at all depths in the boring.

Miliolina macilenta, Brady. (Pl. IX, Fig. 4.)

Diameter 1·0 mm.

Miliolina seminulum, Linné.

Diameter 2·0 mm.

Spiroloculina tenuiseptata, Brady. (Pl. IX, Fig. 5.)

Longest diameter 1·0 mm. It is questionable if this is distinct from *Sp. limbata*, Orb.

Bolivina punctata, Orb.

Minute *Bolivinæ* are as abundant in this rock as in most of the Microzoic formations of the island.

[1] Plates VIII and IX, illustrating the Foraminifera, will appear in the concluding part of Mr. Guppy's paper.

Bulimina inflata, Seguenza.

Textularia sagittula, Defrance. (Pl. IX, Fig. 6.)

Length 1·0 mm. Fairly abundant in some samples.

Textularia gramen, Orb. (Pl. IX, Fig. 18.)

Length 1·0 mm.

Textularia carinata, Hantk. (Pl. IX, Fig. 7.)

Length 1·5 mm.

Textularia trochus, Orb. (Pl. IX, Fig. 8.)

Diameter 1·0 mm., height 1·5 mm. I take *T. turris* and *T. Bareti* to be merely varietal forms of this species.

Textularia aspera, Brady. (Pl. IX, Fig. 17.)

Only three examples were found, of which one (much the largest) measured 3 mm. in length.

Nodosaria raphanistrum, Linn. (Pl. IX, Fig. 9.)

The form found here is identical with *N. bacillum*, Defr., as found in the Vienna Basin and elsewhere. The synonymy of the species includes *raphanus*, *Zippei*, *badenensis*, *acuta*, and many others. It is probably not distinct from *N. obliqua*, the larger and more strongly ribbed forms being found in shallow water, while the smaller, more delicately costate forms come from deeper water. *N. raphanistrum* is not found in the oceanic beds. The longest specimen from the Sangregrande boring is 5·5 mm. in length; it is broken. Some smaller examples are perfect.

Nodosaria obliqua, Linn. (Pl. IX, Fig. 10.)

The form found in the Sangregrande boring is *N. vertebralis*, Batsch, which is only one of the many names conferred upon more or less distinct varieties of this species. The length of our longest specimen is 3·5 mm.

Nodosaria soluta, Reuss. (Pl. IX, Fig. 11.)

Our specimens are generally of the curved variety, with little or no constriction between the segments except perhaps one or two of the later ones. It is exactly the same as *N. elegans* of the Vienna Basin. The examples are usually about 2·3 mm. long.

Cristellaria rotulata, Lam. (Pl. IX, Fig. 12.)

Under this I include *C. calcar* and *C. cultrata*, as the forms found here are somewhat intermediate. It is mostly small, the largest being 2 mm. in diameter.

Cristellaria aculeata, Orb. (Pl. IX, Fig. 13.)

Similar to the Pointapier specimens, except that the last whorl is seldom so much produced. Longest diameter 2 mm.

Uvigerina (Sagrina) raphanus, Parker & Jones. (Pl. IX, Fig. 14.)

The specimens are about 1·3 mm. in length. The species is very abundant at all depths in the Sangregrande boring. It is the short

form resembling fig. 23 of pl. lxxv of the "Challenger" Report. Brady says it is essentially a coral-reef foraminifer, but the conditions of the Sangregrande deposit would not admit of coral-reefs. Our form may be said to be indicative of shallow water, and a depth of 10 to 50 fathoms would probably suit it best. A very few specimens of the long form have occurred to me in the Naparima oceanic beds, and I think that this long form belongs to deep water.

Brady ("Challenger" Report, p. 580) admits that the term *Sagrina* is not required.

Uvigerina canariensis, Orb.

Length about 0·6 mm. Specimens sometimes slightly costate.

Polymorphina lanceolata, Reuss.

A few very minute examples for which the above name may stand until fuller information is obtained.

Globigerina bulloides, Orb.

The forms found at Sangregrande resemble most the Vienna Basin specimens, and do not attain the great development in number, size, or variety that we find in the Naparima oceanic beds.

Sphæroidina bulloides, Orb.

Not very common.

Planorbulina (Discorbina) elegans, Orb. (Pl. IX, Fig. 15.)

Diameter about 0·5 mm. This agrees fairly well with the figure of D'Orbigny's Modèle No. 42 given by Parker & Jones, but not quite as well with the figure given by Goës (Carib. Rhiz., pl. viii, figs. 269–71), which is *R. complanata*, Orb. It suggested itself to me as a small and delicate modification of *Planorbulina Wullerstorfi*, a common and well-developed foraminifer in the oceanic beds of Naparima.

It has been proposed to dispense with the genus *Anomalina*, and to include the species classed under that name, together with those comprised under *Truncatulina*, in the genus *Planorbulina*. In my lists no species from the oceanic beds appears under the name of *Planorbulina*, but some five species are recorded under that of *Anomalina*. *Pl. larvata*, a remarkable form, is recorded from the shallow-water beds, and I have since found it in the *Ditrupa*-bed of Pointapier.

Planorbulina ungeriana, Orb.

One or two small specimens of this species occur.

Pulvinulina elegans, Orb. (Pl. IX, Fig. 16.)

Specimens few and small; the largest was 1 mm. in diameter. This species as a fossil can always be distinguished by its coloration, its white septal bands, marginal rings, and umbilical boss, contrasting with the chocolate-brown interspaces. The Sangregrande specimens are perhaps referable to the var. *partschiana*.

The Sangregrande Borings.—Part II.

Since writing Part I of this paper I have been favoured by the Hon. Walsh Wrightson, C.M.G., Director of Public Works, with reduced diagrams of the three borings made at Cunapo, near Sangregrande, for the purpose of ascertaining particulars relative to the coal-seams in that neighbourhood, and with access to the samples of the cores brought up. These extend our knowledge of the geological conditions very considerably. In Part I of this paper I gave a description of the rocks and fossils of boring No. 3. The diagram of this boring (Plate VII) shows that from 200 feet to the bottom of the boring at 600 feet the composition of the strata is nearly uniform, being the foraminiferal sandstone I have described. This deposit probably recurs in boring No. 2 (82 to 132 feet) and boring No. 1 (90 to 486 feet). At 12 to 18 feet in boring No. 3 there is an ancient river-bed with very hard compact cherty stones, similar to those found in some of the existing river-beds. I do not think that the material of these stones exists anywhere in the form of a continuous layer or stratum, or, if they do, such layer is not of any great extent. It probably exists as lenticular or nodular masses varying in size, and when the containing softer material is carried off these hard stones remain in the river-beds. So with the Naparima rocks near Sanfernando, the harder masses remain heaped upon the beach, while the softer material in which they were imbedded is carried away.

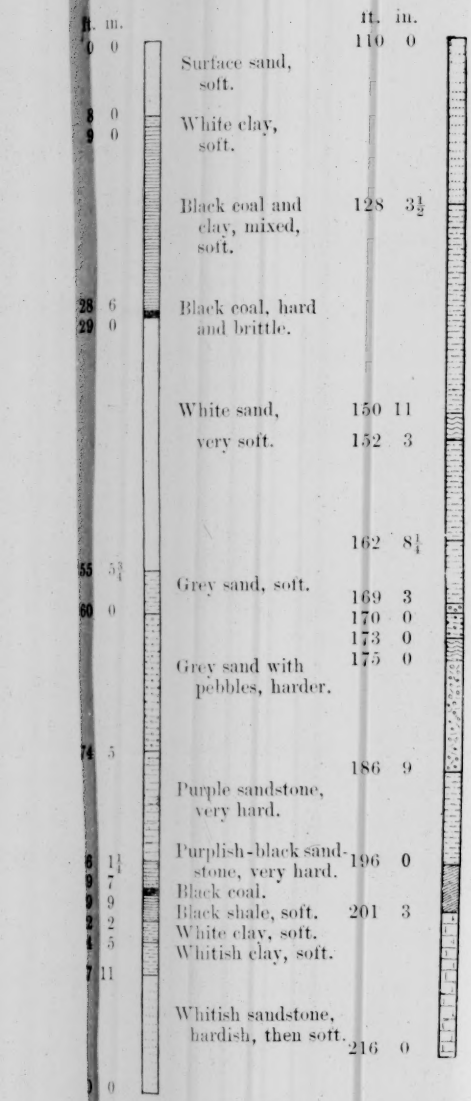
With the exception of two small seams, one of 6 inches at 29 feet, and one of 2 inches at 89 feet, no coal was encountered in any of the borings. Nevertheless, the composition of the strata at the top of each of these borings indicates perhaps littoral conditions or at least shallower water than the material deeper down in the borings. The bed underlying the coal-seam at 89 feet in boring No. 1 is a soft black argillaceous rock with very fine sand, impressions of plant remains, and small bits of coal. This stratum, less than 3 feet thick, is confusedly bedded, and represents, I think, the bottom bed and very beginning of the coal series.

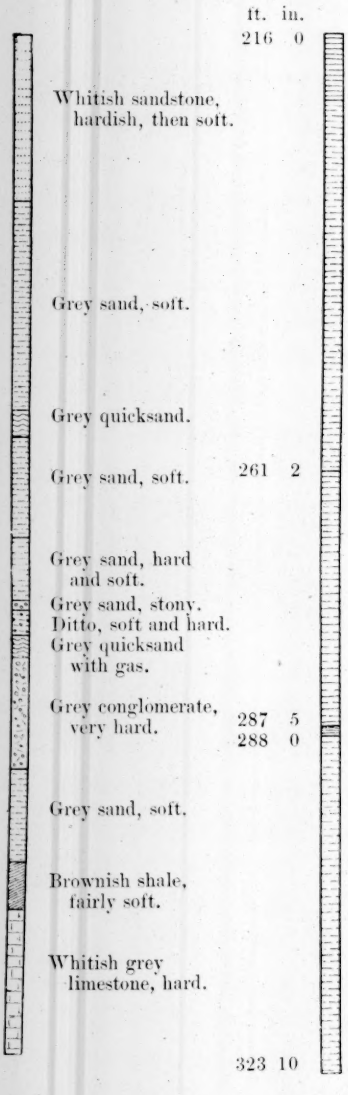
The problem of the relation of the strata pierced by these borings to the coal-bearing series is now before us. These strata are, with a slight exception, of marine formation: are they above or below the coal series?

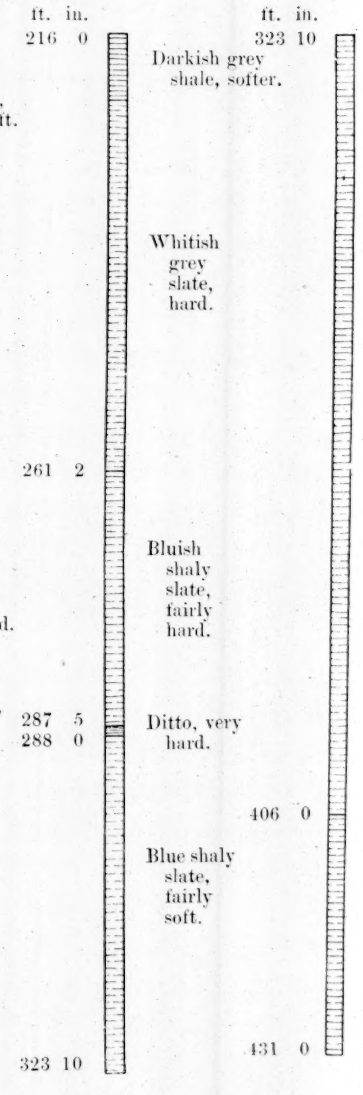
So far as we can judge from the information now at hand, it would seem that they are below. If they were above it would follow that there had been a depression of land since the deposition of the coal in order to admit of the deposit of a marine formation above it. But taking all the known circumstances into account, I think this unlikely. There was probably a movement of upheaval continued throughout the Miocene period which raised the Cretaceo-Tertiary series of Montserrat (including the Manzanilla Eocene formations) above the level of the sea, leaving an arm of the sea between the Montserrat Range and the Parian Range. Into this channel the river Guarapiche (taking its rise and upper course in Venezuela) emptied itself, and

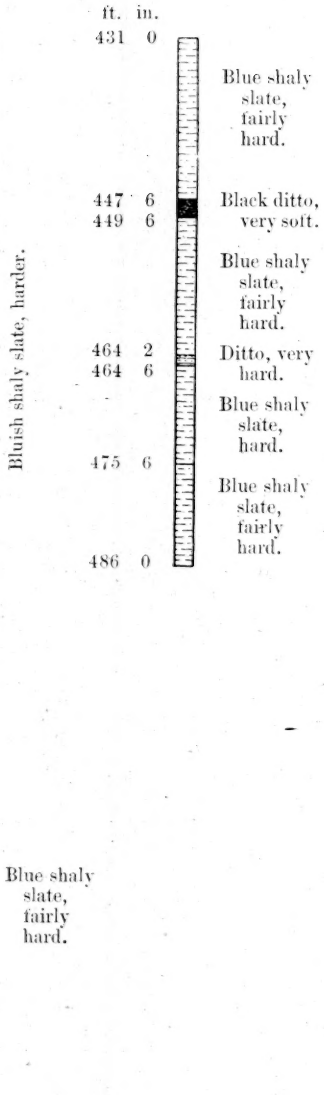
CUNAPO COAL

Diagram of Bore No. 1.









Diagram

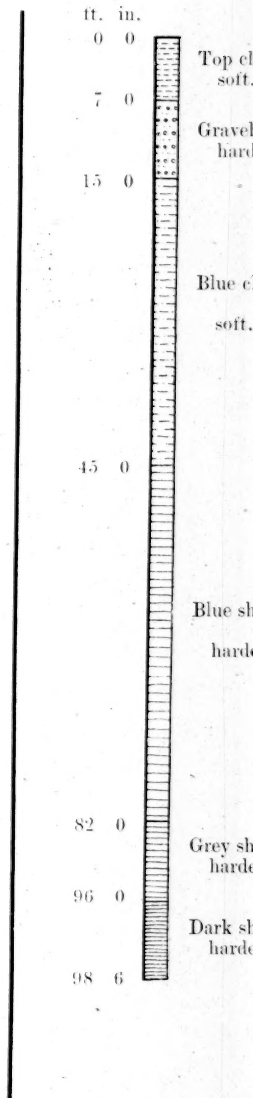


DIAGRAM OF THE BORINGS MADE AT CUNAPO,

TO ILLUSTRATE MR. R. J. LECHMERE G

ALFIELD.

ram of Bore No. 2.

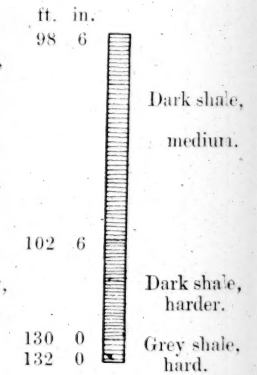
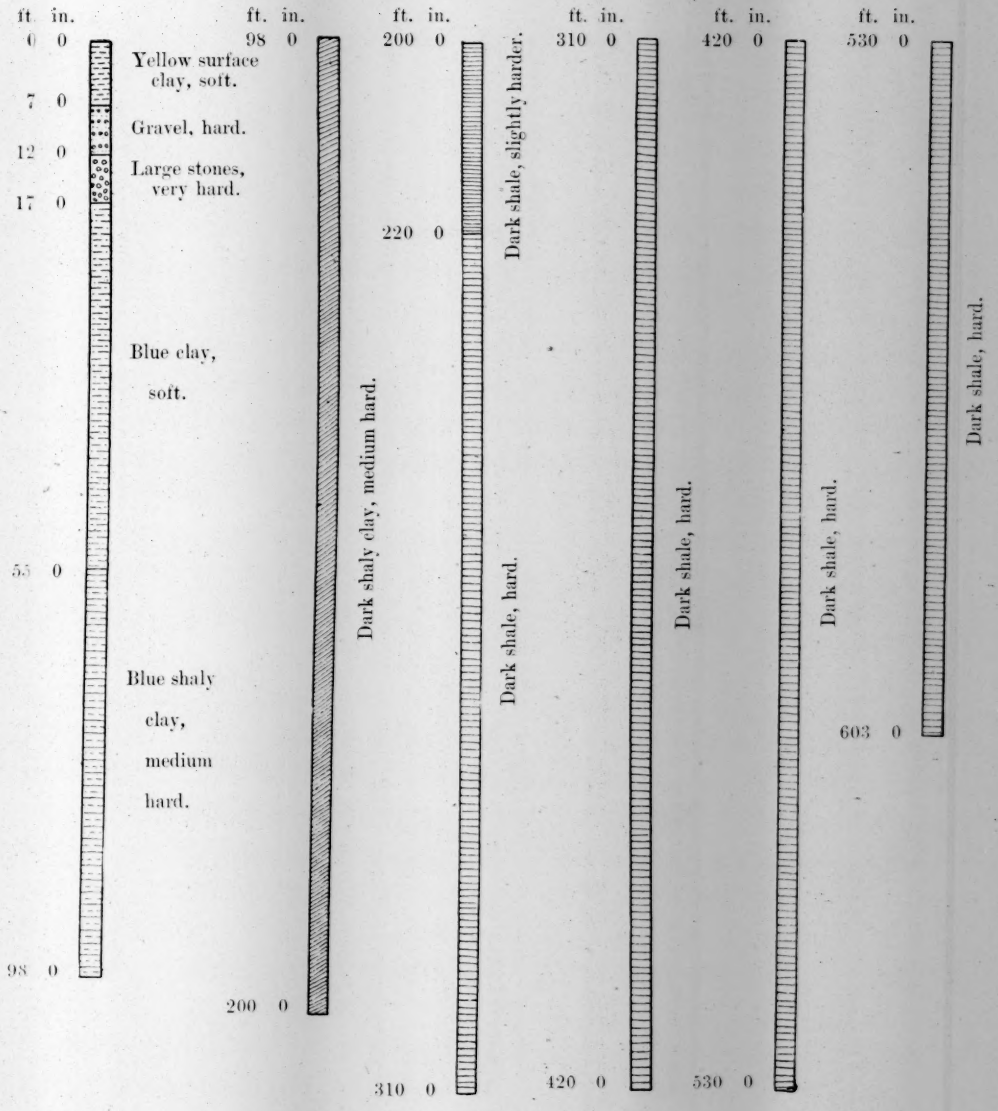


Diagram of Bore No. 3.



D, NEAR SANGREGRANDE, TRINIDAD:

E GUPPY'S ARTICLE.

as this channel was filled up by the fossiliferous sands and other deposits the coal-bearing series followed under estuarine and fluviatile conditions. Therefore I think that these borings pierce strata inferior to the coal series.

In some parts of the Caroni and Oropuch country occurs a large estuarine formation which, in my opinion, succeeded the Miocene formation, and was deposited by the Miocene and Pliocene extension just mentioned of the river Guarapiche (see my papers in Geological Society's Journal, 1892; Geological Magazine, 1900; and Proceedings Victoria Institute, Trinidad, 1902). It is a very fine-grained argillaceous formation, frequently capped by fresh-water gravels, and this may very probably overlie the coal series in places.

Note.—I am informed that at the site of the borings near the Cunapo river, about seven miles from Sangregrande, the surface is about 150 feet above sea-level.

Second Note.—In reference to the conclusions arrived at from this imperfect study of the geology of the Sangregrande district, I may quote a remark by S. A. Miller in his "North American Geology," etc., that "a general knowledge of geology is probably of greater importance to the people of the United States than a like amount of information in any other department of natural science," a remark which might be extended to a larger area than the United States.

EXPLANATION OF FOLDING PLATE VII.

Diagrams showing the strata passed through in the Sangregrande Borings Nos. 1, 2, 3.

(*To be continued.*)

II.—Some Graptolite Zones in the Arenig Rocks of Wales.

By Gertrude L. Elles, Newnham College, Cambridge.

THE Arenig Series, as originally defined by Sedgwick, has undergone much subsequent modification by its founder and other authors. There have been separated off from it the Tremadoc Series at the base, and the Llandeilo Series above, and a certain amount of ambiguity has arisen as to what constitutes the Arenig thus restricted; possibly, therefore, the recognition of three well-defined graptolite sub-faunas within the series in certain districts may help in some degree towards the solution of the problem.

In both North and South Wales there appears to be a well-defined belt of rocks characterised by graptolites of the 'tuning-fork' type (dependent series). In South Wales this constitutes Hicks' Llanvirn Group; it comprises two zones—

1. Zone of *Didymograptus Murchisoni*.
2. Zone of *Didymograptus bifidus*.

The upper zone of *D. Murchisoni* is the equivalent of the beds forming the lower part of the Llandeilo Series, including the Llandeilo Limestone, in part at any rate; the lower zone of *D. bifidus* is the uppermost limit of the Arenig Series.

While the occurrence of one or other, or both, of these zones has been indicated by Matley[1] and Fearnsides[2] in North Wales, and by Marr & Roberts,[3] Crosfield & Skeat,[4] and the officers of the Geological Survey[5] in South Wales, so far as I am aware, it has not been so generally recognised that this belt of rocks characterised by 'tuning-fork' graptolites gives place downward to a belt of rocks characterised by graptolites of the 'extensiform' type (horizontal series) wherever the graptolitic facies of the rocks is developed. This belt characterised by 'extensiform' graptolites may also be divided into two zones—

1. An upper zone of *Didymograptus hirundo*.
2. A lower zone of *Didymograptus extensus*.

The succession of these zones has been determined in widely separated areas, and other localities will no doubt be found in the future, so the object of the following notes is to indicate where they are at present known to occur, and the characteristic association of the graptolites which constitute the sub-faunas.

There are then, three well-defined graptolite zones in the Arenig rocks of Wales—

1. The zone of *Didymograptus bifidus*.
2. The zone of *Didymograptus hirundo*.
3. The zone of *Didymograptus extensus*.

These probably represent the upper part of the series only.

The following are the principal localities where they may be studied :—

River Seiont. (Fig. 1.)

The occurrence of fossils in the rocks in the neighbourhood of Pont Seiont was indicated long ago by Ramsay[6] and later by Marr.[7] The rocks present a certain amount of variation in lithological character, but have a practically identical fauna; they are for the most part sandy or slightly micaceous blue-black shales with a few calcareous bands. They are well exposed on the left of the road before reaching the white gates into the Public Park, and again just beyond the gates, though at this point they have been somewhat altered by the intrusion of a dyke of diabase. The fossils collected from these beds include—

Didymograptus bifidus, Hall (very common).
Diplograptus dentatus, Brong.
Climacograptus confertus, Lapw.
Cl. Scharenbergi, Lapw.
Caryocaris, sp.

The beds clearly, therefore, must be regarded as belonging to the zone of *D. bifidus*.

[1] Geol. Mag., 1902, p. 118.
[2] Brit. Assoc., 1903.
[3] Quart. Journ. Geol. Soc., 1885, p. 476.
[4] Quart. Journ. Geol. Soc., 1896, p. 523.
[5] Summary of Progress, 1902.
[6] Mem. Geol. Survey, vol. iii, p. 161.
[7] Quart. Journ. Geol. Soc., 1876, p. 134.

Marr also recorded fossils from the old tramway near Pont Seiont on the left bank of the river, but so far as I am aware the beds exposed from Pont Seiont to the mouth of the river have never been described in detail, and since they contain three clearly defined graptolitic faunas the succession is not devoid of interest.

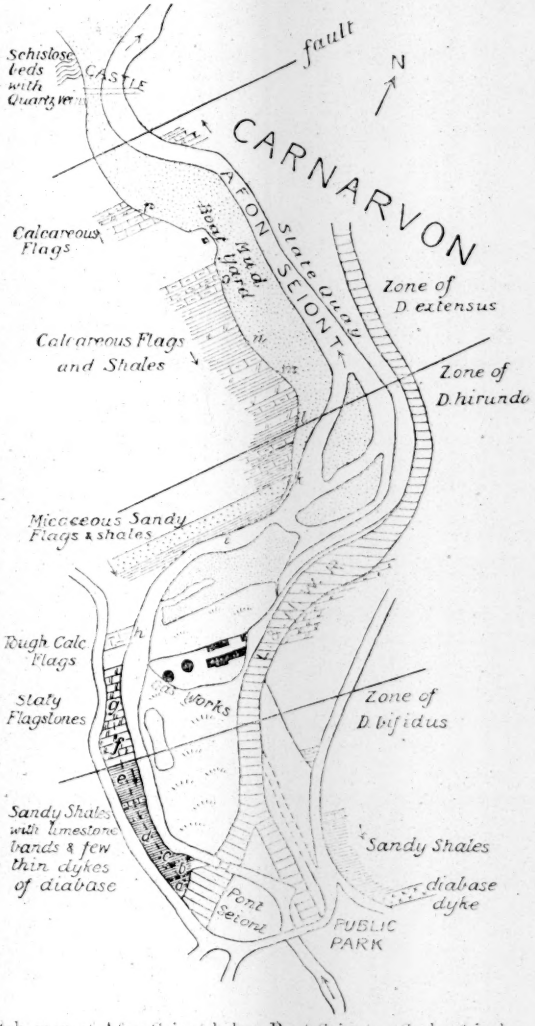


FIG. 1.—Sketch-map of Afon Seiont below Pont Seiont. Scale, 6 inches = 1 mile.

(a) *Left Bank.*

The beds are first seen below the bridge to the west of the railway, along the cutting made for the Nantlle Tramway, long

disused, and now much overgrown. For 200 yards north-west of this point *a*, the beds consist of sandy or slightly micaceous bluish-black shales with narrow limestone bands, dipping S.E. at angles of 40°–50°; they are invaded by a few thin dykes of diabase not exceeding one foot in thickness; between points *a*–*e* indicated on the map they have yielded numerous specimens of *Didymograptus bifidus*, Hall, *Æglina* (*Cyclopyge*) *binodosa*, Salt., *Placoparia*, sp., *Caryocaris Wrightii*, *C. Marri*, Hicks, *Entomidella Marri*, Hicks, sp., *Acrotreta*? and *Lingula*, sp.; they therefore belong to the zone of *D. bifidus*. Beds somewhat more slaty in character underlie these to the north-west, and at a point *f* due east of the bend in the road above, have yielded a characteristic assemblage of graptolites. Here, however, the fauna has changed its character; the 'tuning-fork' graptolites are found no more, while the predominant forms are those of the 'extensiform' or horizontal type, *Didymograptus hirundo*, Salt., and *D. nitidus*, Hall, being the characteristic fossils of the beds exposed between the points *f* and *g* of the map. At this point *g*, due south of the Gasworks, the tramway cutting ends, and opposite the Gasworks the section is much obscured by drift; descending to the shore it is, however, soon continued in a north-west direction by a series of tough calcareous flags with concretions *h*, in which, however, no identifiable fossils were found. These highly calcareous beds are underlain by a series of micaceous sandy flags and shales *i*, which extend round the bend of the river; they have yielded numerous specimens of *D. hirundo* and *D. nitidus*, a solitary specimen of *D. extensus*, *Placoparia*, sp., and numerous Phyllopods. A little further to the north-west bluish calcareous flags weathering brown are seen to pass under the micaceous beds: these beds have also yielded *D. hirundo* and *D. nitidus*, but fossils are not abundant, except at *k*, where in a more shaly band *D. hirundo* is especially common. From this point to the Boatyard a series of calcareous flags with shaly partings is exposed in continuous downward succession; they dip slightly more E. than the higher beds, but the inclination is the same in amount. The fauna also changes its character somewhat, for while the beds from *k* to the old tramway contain *D. hirundo* as the characteristic fossil, and therefore constitute the zone of *D. hirundo*, in the beds from *k* to the Boatyard *D. hirundo* is rare, and the common graptolite still of the 'extensiform' or horizontal type is *D. extensus* itself; this fossil is found in abundance at *m*, and less commonly at *l* and *n*; with it at *m* are also found *D. hirundo* (rare), *Azygograptus suecicus*, Mbg. (one specimen), *Æglina* (*Cyclopyge*) *binodosa*, Salt., and numerous Phyllopods. These flaggy beds must therefore be regarded as belonging to the zone of *D. extensus*.

Beyond the Boatyard some calcareous flags occur, which have, however, yielded no organic remains other than Phyllopods; they are seen to be dipping W.N.W. in an opposite direction to those above the Boatyard, and are probably the same beds slightly disturbed by the proximity of the Bangor–Carnarvon fault. There is then a break in the succession, and the next beds, seen at the

corner beyond the ferry house and bridge, are much contorted and disturbed, and of a nature totally different from any of those just described. The Arenig Series seems to be terminated by the Bangor–Carnarvon fault, which crosses the river close to the Castle and brings on the contorted beds.

(b) *Right Bank.*

A similar but less complete succession may be found on the right bank of the river below the beds previously described by Marr (loc. cit.). Flags which seem to belong to the zone of *D. hirundo* are exposed in the railway cutting at two points, and below the Castle the calcareous flags, which form the lowest visible members of the Arenig Series in this district, are seen again.

The zone of *D. bifidus* is also seen in a quarry by the mill near the Brickworks, where the river makes a big bend, doubling back on itself for a short distance and then continuing in a direction almost at right angles to its previous course. The beds are here bent into a slight fold, the centre of which is occupied by greatly slickensided calcareous flags; graptolites are found in the associated thinly bedded shales, which are much iron-stained; in general the fauna resembles that of the beds at Pont Seiont, but the *Didymograpti* are rarer and the Diplograptidæ relatively more abundant. The beds have yielded—

Didymograptus bifidus (Hall), rare. *Climacograptus confertus*, Lapw.
Diplograptus dentatus, Brong.

Beds on approximately the same horizon are also exposed at Peblig Mill, where greasy blue-grey calcareous mudstones are seen in the quarry below about 20 feet of drift. They are underlain at the north end by a series of lighter-coloured ochreous flags with darker bands, which give place downward to blue-grey mudstones.

The only fossils obtained from this locality were *Didymograptus bifidus* and *Diplograptus dentatus*, both found only after much searching.

Menai Straits.

Closely connected with the lowest beds seen in the Seiont River, though shifted slightly to the north-west by the Bangor–Carnarvon fault, are the beds which come out on the Menai Straits beneath the Carboniferous rocks, and to which attention was first directed by Greenly (Geol. Mag., 1898, p. 560). The beds are well exposed at low tide between the Suspension and Tubular Bridges. Working westwards from the Suspension Bridge, the nearly horizontal Carboniferous beds are at first all that is visible, but shortly some fissile red-coloured slaty beds appear beneath them with a general E.S.E. dip. They are at first only observable on the foreshore, but soon rise into a low cliff, then disappear beneath the Carboniferous, to reappear before reaching the rocky point opposite the rocks in the Strait known as the Swillies. They form the rocky point itself, and an examination of them shows that the red colouring characteristic of the higher beds is merely due to staining; the

lower beds are uncleaved fissile blue-black shales with some calcareous flaggy bands. Numerous graptolites can be obtained at this point, and are particularly abundant in the more shaly bands, especially in a band close below the limit of staining.

I have collected the following fossils from this locality:—

Didymograptus extensus, Hall.	*Tetragraptus serra*, Brong.
D. Nicholsoni, Lapw.	*T. Amii*, Lapw.
D. nitidus, Hall.	*Caryocaris*, sp.
D. gibberulus, Nich.	*Lingulella*, sp.
D. cf. *uniformis*, Elles & Wood.	Trilobite (indet.).

Didymograptus extensus is an abundant form, and the beds seem therefore to belong to the zone of *D. extensus*, though I consider the presence of *Tetragrapti* indicates that the beds are somewhat lower down in the zone than those of the Seiont River.

Lleyn Peninsula.

In the neighbourhood of Aberdaron Matley has described several localities where Arenig rocks may be found (loc. cit., p. 118). He groups these into two districts, the eastern and the western.

(a) *Eastern District.*

The succession and mutual relation of the beds is best indicated in the eastern district near Llanfaelrhys.

As Matley (and previously Tawney) have indicated, the Penarfynydd shales contain numerous and excellent specimens of *Didymograptus bifidus*, as well as some trilobites and other fossils; these, therefore, represent the zone of *D. bifidus*. They are well exposed on the north side of Mynydd Penarfynydd, south and south-east of Penarfynydd Farm, and Matley has shown that the same shales are again seen on the coast between Porth Llawenan and Porth Alwm. They occur here between two dolerite sills, and seem to be faulted slightly out of their normal position. Further west excellent exposures of a series of slaty shales, mudstones, and ironstones are seen in the little gorge of Nant y Gadwen, and are termed by Matley the Nant y Gadwen shales. These shales belong to the zone of *D. hirundo* and the zone of *D. extensus*. The upper, more slaty beds, which are now best seen on the east side of the gorge and contain *Didymograptus hirundo*, *D. nitidus*, and *Azygograptus suecicus*, constitute the zone of *D. hirundo*; while the lower, more sandy beds of the extreme west side of the gorge seem to belong to the zone of *D. extensus*, since they have yielded the following graptolites:—

Didymograptus extensus, Hall.	*Tetragraptus Amii*, Lapw.
D. nitidus, Hall.	*T.* cf. *Headi*, Hall.
D. gibberulus, Nich.	*Trinucleus Gibbsi*, Salt.?
D. uniformis, Elles & Wood.	*Calymene*, sp.

These lower beds have a fauna almost identical with that of the Arenig beds of Menai Straits.

The fauna of the beds of the manganese-works of Benallt, near Rhiw, seems to be that of the zone of *D. hirundo*.

(b) *Western District.*

In the western or Aberdaron tract the masses of shale are for the most part faulted patches, and the only idea of their place in the succession is obtained from the fauna they contain.

The shales seen at Parwyd, since they contain *Didymograptus hirundo* and *Azygograptus suecicus*, seem to represent the zone of *D. hirundo*, while the lower zone of *D. extensus* appears to be represented by the beds at Porth Mendwy, though the graptolites here are rather fragmentary, and it is certainly exposed in the quarry opposite Dwyrhos Farm, where numerous, though badly preserved, specimens of the zone fossil may be obtained.

ARENIG. (Figs. 2 and 3.)

In the Arenig district there are two graptolite-bearing shale bands associated with the volcanic group. One occurs in the middle of

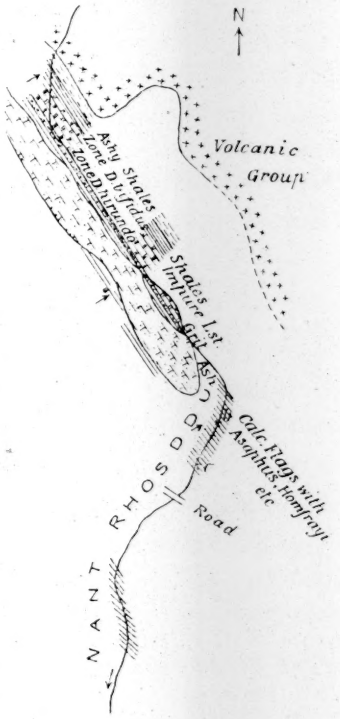


FIG. 2.—Sketch-map of Nant Rhos Ddu. Scale, 6 inches = $\frac{1}{4}$ mile.

the volcanic series, the other underlies it, and both have hitherto been regarded as being of Arenig age. The upper shale band, known to some as the Daear Fawr shale, contains Diplograptidæ and a few Dicranograptidæ: the *Diplograpti*, which are chiefly

Diplograptus foliaceus, var., and *Diplograptus angustifolius*, Hall, are not of the type commonly met with in the Arenig beds of other localities, but, on the contrary, are of the type characteristic of the beds of other areas now generally regarded as being of Llandeilo age; the occurrence of *Dicellograptus Moffatensis*, Carr, and a *Dicranograptus* points the same way. With this shale band, therefore, I am not at present concerned, though its fauna is clearly of interest as bearing on the age of the volcanic group as a whole; it is possibly the equivalent of the middle and upper slates of the Moelwyn district.[1] The lower shale band underlies the main volcanic group and contains two zones, the zone of *D. bifidus* above and the zone of *D. hirundo* below. The succession may be studied on the slopes of Arenig Fach and Arenig Fawr.

On the side of Arenig Fach there rises a little stream, Nant rhos ddu, which flows at first in a S. 15° W. direction, then bends abruptly, running approximately south-south-east for a short distance, but soon resuming its former direction, crosses the Bala–Ffestiniog road about 160 yards below Taihirion Farm, and ultimately runs south to join the river Tryweryn. A series of shales, impure limestones, and gritty beds are exposed in the little gorge made by the stream when it runs south-south-east, and also where it resumes its south-west direction above and below the road.

The general succession is as follows (Figs. 2 and 3) :—

		feet.
	8. Felspathic ash of main volcanic group.	
Arenig.	7. Banded slates with light-coloured ashy bands (fossiliferous)	6
	6. Blue-black slates with graptolites in bands	3
	5. Impure limestones with few shale partings containing a few graptolites	4½
	4. Grit with shale wisps	4
Tremadoc.	3. Calcareous flags.	
	2. Ash.	
	1. Calcareous slates and flags (fossiliferous).	

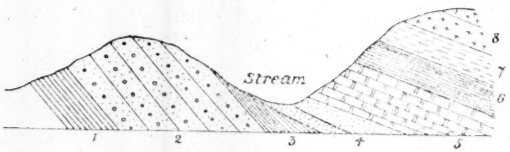


Fig. 3.—Diagrammatic Section across Nant Rhos Ddu. Vertical scale exaggerated.

The Arenig beds dip E. 25° N. at 20°, they are strongly cleaved, the cleavage making with the bedding an angle of about 20°. Some of the ashy bands of the uppermost series have yielded *Oggygia Selwyni* (Salt.) and other fossils, and the blue-black slates which underlie them have yielded graptolites characteristic of the zone of *D. bifidus*, namely, *D. bifidus*, Hall, *Diplograptus dentatus*, Brong., and *Climacograptus confertus*, Lapw. The only fossiliferous band among the impure limestones is at the very base where it rests

[1] Quart. Journ. Geol. Soc., 1891, p. 368.

upon the grit, and this has yielded a few specimens of *D. hirundo* and seems to indicate the highest bed of that zone. The grit which underlies the limestones appears to rest unconformably upon calcareous flags, and in these and the beds beneath it is worthy of note that the dip practically coincides with the cleavage, and hence the difference in dip between the two series, while similar in direction, differs to the amount of about 20°. There may also be some faulting along this line. The ash of the lower series seems to be a lenticular patch; it never crosses Nant rhos ddu, and its presence seems to be the factor determining the south-south-east course of the stream, for with its appearance the stream turns south-south-east, and with its disappearance resumes its original direction. The age of the lower series seems to be sufficiently determined by the presence of *Asaphus Homfrayi*, Salt., *Agnostus*, sp., and *Olenus triarthrus*, Walc., which have been found in several localities in beds dipping 40° E.N.E. They seem to be the beds designated Lower Arenig by the officers of the Geological Survey.[1] The Arenig beds are probably present below the ash band on the slopes of Ffridd Bwlch-llestre; they are, however, only exposed at one other locality, namely, in the stream north-east of Bryn-maenllifo, where they are found beneath the basal agglomerate of the main volcanic group.

On the other side of the valley the most continuous exposure of the Arenig beds is found on the north-west slopes of Arenig Fawr, in the stream running down to Hafodty Milltir Cerig (Hafody Filltir Gerig). Here the succession is as follows:—

Felspathic ash (?) of main volcanic group.
- Thickly bedded ashes, ashy flags, and shales, with *Ogygia Selwyni* (Salt.), *Monoholina* (*Obolella*) *plumbea*, *Maclurea*, sp., *Calymene*, sp.
- Thinly bedded slates and flags with *D. bifidus*.
- Grits.
- Finely bedded banded shales.

Diabase intrusion.

The thickly bedded ashes, ashy flags, and shales are very like those of the Taihirion side, but somewhat thicker, and the underlying slates contain *D. bifidus* and seem to represent the zone of *D. bifidus*.

The lower zone of *D. hirundo* is probably also present, since in a collection made by Professor Hughes from this locality there are several specimens of *Azygograptus suecicus* in an impure limestone, and *Az. suecicus* is commonly found associated with *D. hirundo* elsewhere; I have not myself, however, detected the zone *in situ*. The rocks below the diabase intrusion seem to be of Tremadoc age.

South Wales.

The graptolite-bearing beds of South Wales, for the sake of convenience, may be considered as belonging to two districts—

(1) Western or St. Davids District.
(2) Eastern or Haverfordwest–Carmarthen District.

[1] "Geology of North Wales," vol. iii.

(1) *Western District.*

Hicks[1] and Hopkinson[2] long ago drew attention to the graptolite-bearing beds of the St. Davids district, and recorded fossils from the mainland and also from Ramsey Island, but while recent work tends to confirm Hicks' view that the beds of Llanvirn and Porth-Hayog were of Upper Arenig age, it tends to modify his conclusions respecting the age of the other graptolite-bearing beds.

(a) *Abereiddy Bay.*

The relation of the lowest Llandeilo beds, forming the zone of *D. Murchisoni*, to the uppermost Arenig slates, constituting the zone of *D. bifidus*, is particularly clear in this western district and worth notice. At the extreme south end of Abereiddy Bay a series of much cleaved black slates, dipping a few degrees W. of N., is seen crowded with *Didymograptus Murchisoni*; ascending the cliff, a well-marked band of felspathic ash separates these black slates from an underlying series of lighter-coloured slates, which can be observed for a considerable distance along the track leading from the spring to Nant; they also dip a few degrees W. of N. at a high angle, and have been extensively quarried in the past. The most fossiliferous beds, as indicated by Hicks, are those in the middle quarry, and from this place and the 'tips' lying north-west of it most of my fossils were obtained.

The beds contain

Didymograptus bifidus, Hall.
D. nanus, Lapw.
D. Nicholsoni, Lapw.
D. patulus, Hall.
D. euodus, Lapw.[3]
Cryptograptus tricornis, Carr.
Glossograptus ciliatus, Emmons.
Diplograptus dentatus, Brong.
Placopacia cambrensis, Hicks.

This light-coloured slate series therefore clearly represents the zone of *D. bifidus*; it is underlain by a succession of grits and flags well exposed in the old quarry near Nant.

(b) *Ramsey Island.*

Beds with a fauna very similar to that just described, but differing somewhat in their lithological characters, were found by Hicks and Hopkinson (loc. cit.) on Ramsey Island at the head of a little creek on the south-west known as Porth-Hayog or Porth Llanog. The beds here are soft black shaly mudstones, sometimes highly micaceous; they dip N.W., and have yielded an abundant fauna, including the following graptolites:—

Didymograptus bifidus, Hall.
D. stabilis, Elles & Wood.
D. artus, Elles & Wood.
D. Nicholsoni, Lapw.
D. affinis, Nich.
Didymograptus acutidens, Lapw.
D. patulus, Hall.
Diplograptus dentatus, Brong.
Climacograptus Scharenbergi, Lapw.
Cl. confertus, Lapw.[3]

[1] Hicks, Brit. Assoc. Rep., 1872, 1873; Quart. Journ. Geol. Soc., 1875, p. 167.
[2] Hopkinson, Brit. Assoc. Rep., 1872, 1873.
[3] Cf. lists of Hicks and Hopkinson, loc. cit., and Hopkinson and Lapworth, Quart. Journ. Geol. Soc., 1875, p. 631.

Possibly the shales, which seem to be responsible for the formation of the little bay south of Trwyn Gaelic, and thence run south-east, belong also to this zone of *D. bifidus*, but I have been unable to determine this with certainty.

The greater part of the black slaty beds forming the cliffs at Road Uchaf and Road Isaf have the fauna characteristic of the higher part of the zone of *D. extensus*; the beds dip landwards at a very high angle, and run approximately north and south. The following fossils occur:—

Didymograptus extensus, Hall.
D. sparsus, Hopk.
D. pennatulus, Hall.
D. gibberulus, Nich.
Trigonograptus ensiformis, Hall.
T. truncatus, Lapw.
Callograptus radiatus (Salt.).
Dendrograptus arbuscula, Salt.
D. flexuosus, Hall.
D. divergens, Hall.
D. diffusus, Hall.
D. Homfrayi, Hopk.
Ptilograptus Hicksi, Hopk.
P. cristata, Hopk.

The higher beds seen possibly represent the lower beds of the zone of *D. hirundo*, since they are crowded with a species of graptolite, *D. sparsus*, closely allied to *D. hirundo*, if not merely a variant of it, and the typical fossil, so far as I am aware, has not yet been recorded from the island; the higher beds of the zone of *D. hirundo* may be present west of Aber Mawr, but they are not well exposed owing to the nature of the country. The rocks may be faulted as Hicks' map would indicate, yet it is remarkable that the graptolite zones occur precisely where they might be expected were the succession normal.

(c) *Whitesand Bay.*

Slaty beds containing an abundant *Dendrograptus* fauna[1] are found on the mainland in Whitesand Bay, north of Trwyn Hwrddyn; they were considered by Hicks to be of the same age as the beds of Road Uchaf and Road Isaf, but the evidence tends, I think, to show that these Whitesand Bay beds are considerably lower in the Arenig Series than any seen on Ramsey Island.

These slaty beds are highly inclined, and dip a few degrees west of north at a high angle, they pass upward into a series of well-bedded slates with gritty bands seen in the old quarry in Porth Llenog, and from these beds there have been obtained—

Azygograptus Hicksi, Hopk.
Tetragraptus Amii, Lapw.
T. quadribrachiatus, Hall.
Didymograptus (*extensus* type).
Clematograptus implicatus, Hopk.
Dendrograptus arbuscula, Hall.
D. flexuosus, Hall.
Callograptus elegans, Hall.
C. Salteri, Hall.[1]

This fauna suggests the lower part of the zone of *D. extensus*, and hence these beds are rather lower than any seen on Ramsey Island; thus the beds which underlie them to the south must be still lower in the series.

These slates pass up into others containing a rich fauna, Trilobites and Brachiopods, but no identifiable graptolites. These are also seen at Porth Melgan, east of St. Davids Head.

[1] Cf. lists of Hicks and Hopkinson, loc. cit.

(2) *Eastern District.*

Further east in South Wales, in the eastern part of the Haverfordwest district, Marr & Roberts[1] have indicated in their '*Didymograptus* shales' the extension eastwards of the zones of *D. Murchisoni* above and *D. bifidus* below. And a collection of fossils made long ago by the late T. Roberts, and now in the Sedgwick Museum, Cambridge, seems clearly to point to the existence of the zone of *D. extensus* at Talfan, near Whitland, since the beds there have yielded *D. extensus*, Hall, *D. nitidus*, Hall, *Tetragraptus serra*, Brong., *T. Amii*, Lapw., *T. Headi*, Hall, *Dendrograptus fruticosus*, Hall,[1] *Callograptus persculptus*, Hopk., and *C. Salteri*, Hall.

In the Carmarthen district Crosfield & Skeat[2] have mapped the zones of *D. Murchisoni* and *D. bifidus* over a considerable tract of country, and the fauna of the shales of Hafod Wen, which they have courteously permitted me to examine, containing as it does both *D. hirundo* and *D. nitidus*, leads me to believe that the Hafod Wen shales represent the zone of *D. hirundo*; the beds of Glan Pibwr possibly indicate the still lower horizon.

Correlation and Conclusions.

	Wales.	Shropshire.	Lake District.	Scania.
Arenig Series.	Zone of *D. Murchisoni*.	Upper Hope Shales.	Millburn Beds?	Zone of *D. geminus*.
	Zone of *D. bifidus*.	Lower Hope Shales.	Ellergill Beds.	Zone of *Glossograptus*.
				Zone of *Phyllograptus* cf. *typus*.
	Zone of *D. hirundo*.	Upper Mytton Flags.	Upper *Tetragraptus* Beds.	Zone of *Isograptus gibberulus*.
	Zone of *D. extensus*.	Shelve Church Beds.		
	?	Lower Mytton Flags.	*Dichograptus* Beds.	Zone of *Phyllograptus densus*.
				Zone of *Didymograptus balticus*.
	Garth Grit?	Stiper Stones Quartzite.	Lower *Tetragraptus* Beds.	Zone of *Tetragraptus phyllograptoides*.
	Tremadoc Beds.	Shineton Shales.	*Bryograptus* Beds.	*Bryograptus* Beds.

The correlation of the Welsh Arenig Series with beds of other areas is indicated in the above table.

The facts noticed about the beds would lead us to suspect that the series is incomplete in Wales, and a comparison with other areas tends to confirm this suspicion.

[1] Loc. cit. [2] Loc. cit.

With the possible exception of the lowest beds of the series seen in Whitesand Bay, there is, so far as our present knowledge goes, nothing comparable with the *Dichograptus* beds of the Lake District or the Lower Mytton Flags of Shropshire. In the Lake District the many branched graptolites are characteristic of this horizon. It is always possible that the beds may not be represented in Wales by the graptolitic facies, but up to the present time no graptolite-bearing beds of true Arenig age have been recorded resting conformably upon the Garth grit of Garth (Portmadoc) and its true equivalents. The beds of Ty Obry and Ty Fry have a fauna more closely allied to that of Llandeilo rocks than to that of any Arenig beds with which I am acquainted. Hence there is the possibility of a break in the succession between the grit of Garth and higher beds; there may be other grits in the series indicating recommencement of deposition, but these are not strictly the equivalents of the grit of Garth.

Table showing Extent of Zones in Wales.

	Menai Straits.	River Seiont.	Aber-daron.	Arenig.	St. Davids.	Car-marthen.
Zone of *D. bifidus* ...						
Zone of *D. hirundo* ...					...?...	
Zone of *D. extensus* ...						

In conclusion, I offer my grateful thanks to Dr. Matley for the loan of his maps of the Lleyn Peninsula, and for advice concerning the working of it; to Dr. J. E. Marr for allowing me to examine his collection of fossils; to Miss H. Drew, of Newnham College, and Mr. W. G. Fearnsides, of Sidney Sussex College, for help in collecting fossils in various places.

III.—Further Notes on the Mammals of the Eocene of Egypt. Part III.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

Among the collections now in Cairo I find several new mammals, the remains of which have been collected by Mr. Beadnell, for the most part during the last few months. Brief descriptions of these new forms are now given in order that the names may be included in the lists in Mr. Beadnell's forthcoming report on the geology of the Fayûm area.

Pterodon macrognathus, sp. nov.

This creodont is known from the nearly complete left ramus of the mandible. The last molar, the first premolar, and the incisors are represented by the alveoli only, but the other teeth, with the exception of the canine, the crown of which is broken off,

are in fairly good condition. The mandible is long and narrow from above downwards, the distance between the last tooth and the condyle being remarkably great. The transversely elongated cylindrical condyle is about on a level with the alveolar border and is separated from the prominent angle by a deep notch; the coronoid region is imperfect. The teeth are not very unlike those of *Pterodon*, but it may subsequently be found necessary to establish a new genus for the present species. The last molar is represented by the alveolus only. M. 2 consists of a high blunt main cusp, a small antero-internal cusp, and a large talon with a blunt cutting edge near its outer side. M. 1 is much smaller than m. 2, but the talon is relatively larger and consists of a distinct tubercle, on the inner side of which there is a prominent cingular ridge. The last premolar (pm. 4) is much larger than m. 1; it consists of a high cusp and a small talon; the cingulum is distinctly developed on the inner side of the tooth. Pm. 3 and pm. 2 are simple conical two-rooted teeth, the crowns being small in comparison with the roots, at least in pm. 3. Pm. 1 was a small one-rooted tooth, squeezed outwards by the large canine, which was oval in section. The three incisors were so crowded together that the median one was situated behind and above the other two.

On the outer side of the jaw beneath the premolars there were four foramina separated by equal intervals. The dental foramen lies far back and is very small. This species may for the present be referred to *Pterodon* under the name *P. macrognathus*.

The dimensions of the type-specimen (No. 8982, Cairo) are:—

	mm.
Total length of the jaw	212
Depth of ramus at hinder end of the symphysis	32
Depth of ramus beneath m. 3	32
Length of symphysis	58
Width of condyle	25
Distance between hinder border of the alveolus of m. 3 and the posterior angle of the condyle	102
Length of the alveolus of m. 3	16
,, m. 2	16
,, m. 1	13
,, pm. 4	17
,, pm. 3	14
,, pm. 2	12
Antero-posterior diameter of canine	20

Geniohyus major, sp. nov. (No. 8980, Cairo).

Three beautifully preserved premolars (pm. 1, 2, 3) indicate the existence of an animal closely similar to *Geniohyus fajumensis*, but much larger, the antero-posterior length of the teeth in the two species being—

	Geniohyus major.	*G. fajumensis*.
pm. 1	18 mm.	13 mm.
pm. 2	19 ,,	14 ,,
pm. 3	20 ,,	15 ,,

In fact, the length of the three anterior premolars in the present species is the same as that of the whole premolar series in *G. fajumensis*. In structure these teeth differ from those of *G. fajumensis* in much

the same way as the latter differ from the premolars of *G. mirus*, that is to say, their selenodont character, particularly of the posterior cusp, is more distinct.

Megalohyrax minor, sp. nov.

A left maxilla (No. 8188, Cairo) with the very well preserved molars and premolars may be taken as the type of this species. Except for their smaller size the teeth are very similar to those of *Megalohyrax eocænus*. The chief differences are that the premolars are somewhat simpler. Thus, pm. 1 has an elongated crown without a postero-internal cusp, and is very similar to the canine of the larger form, and in the same way the succeeding premolars each resembles the tooth in front of it in *M. eocænus*. Another peculiarity is that the parastyle is better developed. The molars are much alike in the two species.

The dimensions of the upper teeth in the type-specimens of *Megalohyrax minor* and *M. eocænus* are given below :—

Length.	*M. minor*.	*M. eocænus*.
m. 3	29 mm.	37 mm.
m. 2	26 ,, ...	37 ,, (approx.).
m. 1	21 ,, ...	30 ,,
pm. 4	17 ,, ...	— ,,
pm. 3	15 ,, ...	25 ,,
pm. 2	14 ,, ...	23 ,,
pm. 1	15 ,, ...	18 ,,

The total length of the molar-premolar series is 13 cm.

Portions of a mandible perhaps referable to this species also occur in the collection. The specimen consists of two pieces, one the greater part of the right ramus with pm. 2–4 and m. 1–3, the other the anterior portion of the left ramus with part of the symphysis, containing pm. 3–4, m. 1–2, and in front two incisors, probably i. 1 and i. 2. The incisors have very broad short spatulate crowns, greatly compressed from within outwards, and bearing a continuous wear-surface along their edges. It is difficult to see how such teeth could have bitten against the large upper incisor, which it has been suggested was present in *Megalohyrax*, but it is not impossible that they may have worked against a ledge on the hinder surface of a tusk-like incisor. Further material is necessary, particularly the anterior portion of a skull of one of the species of this genus.

The molars and premolars each consist of two crescents, and from the inner end of the hinder limb of the anterior crescent a short ridge runs back on the inner side of the tooth, partly closing the opening of the hinder V of the tooth. The posterior premolars and anterior molars are alike. The dimensions of the teeth are :—

	Length.	Greatest width.
m. 3	33 mm.	20 mm.
m. 2	23 ,, ...	18 ,,
m. 1	19 ,, ...	16 ,,
pm. 4	18 ,, ...	16 ,,
pm. 3	16 ,, ...	14 ,,
pm. 2	17 ,, ...	11 ,,

Length of series from pm. 2 to m. 3 inclusive, 12·7 cm.
The width of the crowns of the incisors are: i. 1, 14 mm.; i. 2, 16 mm.

Saghatherium magnum, sp. nov.

Further examination of the type of *Saghatherium antiquum* in the museum at Cairo shows that a specimen of the upper dentition preserved in the British Museum, which I had regarded as belonging to that species, is actually much larger and differs slightly in some other points. I propose, therefore, to make this specimen the type of a new species, *Saghatherium magnum*. The approximate dimensions, compared with those of the type of *S. antiquum*, are :—

Length.	*S. magnum.*	*S. antiquum.*
Cheek teeth (molars, premolars, and canine) ...	78 mm.	62 mm.
Premolar series	32 ,,	25 ,,
Molar series	39 ,,	31 ,,
m. 3	17 ,,	15 ,,
m. 2	15 ,,	14 ,,
m. 1	10 ,,	11 ,,
pm. 4	10 ,,	8 ,,
pm. 3	9 ,,	7 ,,
pm. 2	8 ,,	6 ,,
pm. 1	8 ,,	6 ,,

The separate teeth are measured along their outer wall.

One of the most striking differences between the two species, other than size, is that in the last molar of *S. magnum* the metastyle is much less developed than in *S. antiquum*.

The anterior portion of the upper jaw showing the large incisor, figured in the Geological Magazine, 1903, p. 340, under the name *S. antiquum*, is actually part of the type-specimen of the present species.

All the species described above are from the Upper Eocene beds of the Fayûm.

Zeuglodon isis, Beadnell MS.

The existence of a large species of *Zeuglodon* other than *Z. osiris*, Dames, in the beds beneath the Qasr-es-Sagha series has already been referred to by Stromer [1] and also in this Magazine (1901, p. 437). Mr. Beadnell refers to this species in his memoir on the geology of the district, which will be published shortly, as *Zeuglodon isis*, and this name is here adopted. The most important specimen, which may be taken as the type, is a right ramus of the mandible complete as far as the back of the tooth series; this was collected from the Birket-el-Qerun beds of the Middle Eocene. The teeth in the anterior portion are lost, but the hinder ones are present, though somewhat broken and obscured by matrix which cannot be removed.

The total length of the specimen is 83 cm. In front it terminates in a blunt point, and is convex from above downwards on its outer face, while the inner face forms a flat symphysial surface for union with the opposite ramus. The depth of the ramus at the second alveolus is about 64 mm., but posteriorly it deepens, till behind the last molar it is about 220 mm. The extreme anterior end is occupied by an empty alveolus, and behind this there are three

[1] "Zeuglodon-reste aus dem Oberen Mitteleocaen des Fajum" : Beitr. Pal. u. Geol. Oster.-Ung. u. d. Orients, Bd. xv, Heft 2 and 3 (1903), p. 83.

other alveoli for single-rooted teeth; these occupy the anterior 26 centimetres of the jaw. The next tooth is *in situ*; its anterior border is 32 cm. from the tip of the jaw. The crown is high and conical, somewhat compressed from side to side, with sharp anterior and posterior edges and slightly curved backwards. On the anterior edge near the base of the tooth there are five or six blunt, upwardly directed denticulations, while on the posterior edge there are four or five larger ones. The height of the tooth crown was 6·5 cm., the length of its base 5 cm. The next tooth, separated from the last by an interval of about 5 cm., was broad and double-rooted; its crown is somewhat broken, but it can be seen that on its anterior and posterior edges there were several large and sharp denticulations. The length of the tooth at its base was about 6·6 cm. The next tooth, which is separated from the last by an interval of 4·5 cm., is similar, as also is the next, which is in contact with that in front. The last three teeth (the molars) differ considerably from those just described. They are closely crowded, and have a nearly straight anterior border, denticulations occurring on their posterior edge only. On the whole the dentition closely resembles that of *Zeuglodon osiris* as figured by Stromer.[1]

A number of very large vertebræ have also been found; the dimensions of one of these are:—Length of centrum, 23·5 cm.; transverse diameter, 17·7 cm.; vertical diameter, 15 cm.

P.S.—In reference to my account of the teeth of *Arsinoitherium* given in the last part of these notes, my attention has been drawn to the fact that in a footnote to one of his geological papers Blanckenhorn has mentioned the similarity between this dentition and that of *Coryphodon*.

Cairo, *April*, 1904.

NOTICES OF MEMOIRS, ETC.

I.—Palæontology in the National Museum, Melbourne.

THE following Report of the Palæontologist of the National Museum, Melbourne, Mr. Frederick Chapman, has recently been issued, and gives a good general idea of the material available for study in that Institution:—

After the preliminary work of unpacking and generally inspecting the collections of fossils placed in my charge, the work of selecting a series of specimens to illustrate Australian, and particularly Victorian, palæontology was commenced. This has been progressing, in conjunction with other necessary work, with the result that there are now on view 15 table-cases of typical Australian fossils, including the Cambrian, Ordovician (Lower and Upper), and the Silurian. I have introduced certain noteworthy features, such as explanatory diagrams and illustrations, into the arrangement of these cases, in order to make them more interesting, both to students

[1] Op. cit., pl. viii, fig. 2.

and the public. Our collections of Palæozoic fossils have been considerably enriched by the purchase of the valuable series formed by the Rev. A. W. Cresswell, M.A., and Mr. F. Spry respectively, and the donation by Mr. G. Sweet, F.G.S., of the entire series of Cambrian fossils now on exhibition. The large fossils and casts have been repaired and repainted, and the whole labelled in accordance with the latest nomenclature. These exhibits are arranged in the Upper Gallery of the Museum on the north-east side, which was thrown open to visitors last November.

I have prepared and hung in the Gallery two long, coloured geological sections, one illustrating the geology of Victoria, running through the State in a west to east direction, and the other taken through Melbourne from Brunswick to Ormond Point, near St. Kilda. Every care has been taken to render these correct according to the latest information, and in working out these details I have been greatly assisted by the friendly help of Professor Gregory, F.R.S., and Mr. T. S. Hall, M.A. One thousand and thirty-seven fossils have been determined, most of which are now exhibited.

Since a large number of the Palæozoic fossils of Victoria are still awaiting description, this work has been taken in hand, and I have figured and described (Proc. Roy. Soc. Vict., vol. xv, pt. 2) fourteen fossils in the National Museum, ten of which are new to science; two new genera have also been established to receive two of these fossils.

The very comprehensive and valuable collection of fossils in the Museum, brought together under the direction of the late Sir Frederick McCoy, was a distinct and agreeable surprise to one who, although familiar with the English national collection, did not anticipate meeting with anything at all comparable in the southern hemisphere; and these, chiefly the foreign specimens, will be most valuable for purposes of comparison with those of Victoria.

II.—Various Short Notices.

1. The subject of "Clastic Dikes" is dealt with by Mr. J. F. Newsom (Bull. Geol. Soc. America, xiv, 227, 1903). He describes a number of sandstone dikes in San Luis Obispo and Santa Cruz counties, California. The rocks of San Luis Obispo are Cretaceous sandstones, overlain by Miocene shales, which are cut by sandstone dikes. These dikes occur near the axis of a low synclinal fold, where former conditions were probably favourable to great hydrostatic pressure. The author is of opinion that soft sands were forced up from below along joint planes, and that the sands were afterwards firmly cemented by calcium carbonate. Near Santa Cruz there are dikes of sandstone, varying from mere films along joint planes to intruded masses several feet thick. These cut the Miocene shales at various angles on the western side of a faulted monoclinal fold. The smaller films are usually bituminous. In the author's opinion there is evidence that the underlying sandstones were formerly oil-bearing, and that the oil-bearing sands were forced into joints in the shales. The larger dikes formed the avenues of escape for the

petroleum, and subsequently for water which carried the oil and oil residues from the intrusions. The author concludes with a very full summary of the literature of Clastic Dikes.

2. Dr. F. H. Hatch has written a brief description of "The Boulder Beds of Ventersdorp, Transvaal" (Trans. Geol. Soc. S. Africa, vi, 95, 1904). The boulder ('banket') beds consist of pebbles and large masses of slate, conglomerate, and quartzite, identical with rocks occurring on the Rand and belonging to the Witwatersrand Beds; and they include also various igneous rocks. Some of the banket boulders have been found to contain gold in payable quantity, but these occurred amid many non-auriferous masses, the fact being that the boulder beds have been derived chiefly from the Witwatersrand Beds upon which they rest unconformably. Dr. Hatch remarks that the boulder beds include not only conglomerates but igneous breccias, and the formation appears to have been initiated by the outpouring of vesicular lavas known as the Klipriversberg Amygdaloid. For the group he applies the term "Ventersdorp Beds."

3. "The Geological History of the Gouritz River System" is the title of an essay by Mr. A. W. Rogers (Trans. S. African Phil. Soc., xiv, 375, 1903). This river system drains the country southwards from the Nieuweveld Ranges, and the principal rivers, after crossing a broad tract of less elevated ground, traverse in succession the mountainous tracts of the Zwartebergen and Langebergen. The author describes the physical changes to which the area has been subjected, and which have led to the present drainage system.

4. An Index to Geological Papers.—Many valuable papers on the geology of Devonshire are scattered through the first thirty-four volumes of the *Transactions* of the Devonshire Association for the Advancement of Science, etc. Vol. xxxv (1903) contains a continuous alphabetical index to these, by Mr. J. G. Hamling, who has placed each paper under three headings, viz., subject, locality, and author. Geologists will be grateful to the compiler, and it is only because he asks for intimation of any mistakes or omissions that we venture to suggest the desirability for an extension of the subject entries; for example, there are only eight entries under 'Caverns' and only eight under 'Fossil,' although the number of papers dealing with those subjects is vastly greater.

5. "Devonshire in the time of the Lower Chalk" is the title of a paper by Mr. Jukes-Browne (Trans. Devon Assoc., xxxv, 787, 1903). An accompanying map shows the probable geography of the south-west of England and north-west of France in the Cenomanian (Lower Chalk) age. Exmoor is represented as an island, while the country south-west of Tintagel and Dartmoor is regarded as part of "the Western Land" connected with Brittany and Normandy.

6. In another paper on "The Geology of the Country around Chard" (Proc. Somerset Arch. and Nat. Hist. Soc., xlix, 1903)

Mr. Jukes-Browne gives a particular account of the Selbornian Sands (Upper Greensand) and Chalk, with an excellent photographic view of the quarry at Snowdon Hill, Chard, famed for its rich fossil-bed at the base of the Chalk.

7. In an article on "The Cotteswold Hills" (Proc. Cottesw. Club, xiv, 205, 1903) Mr. S. S. Buckman discusses the area of the Cotteswolds, the spelling of the name, and other matters of topographical interest—entering fully into the literature of the subject. A map on the scale of an inch to 4 miles accompanies the article, and on it he has marked the limits he is led to assign to the Cotteswold Hills and the names of the bordering vales. To aid in his decision he has sought the best advice from residents and others. The greatest difficulty in fixing a boundary was in the region east of Burford, a tract sometimes spoken of as the Oxford or Oxfordshire Downs. With regard to this term Lord Moreton writes that it is not a geographical expression, but "simply means the sheep of Oxfordshire of a down character." The Cotteswold Hills as now marked out extend from Ebrington Hill on the north to Lansdown by Bath on the south. The western limit is naturally bounded by the escarpment of the Oolites. The eastern limit is taken to include Badminton (but not Malmesbury), Tetbury, Cirencester, Fairford (but not Witney), Leafield, and the western side of the Vale of Moreton. Names of places where the Cotteswold Club has held field-meetings are marked on the map, showing plainly that the Club has trespassed far and wide into bordering tracts. A full list of the field-meetings, drawn up by Mr. L. Richardson, is appended. —H. B. W.

8. Labelling of Objects in the Geological Department, British Museum of Natural History.—Much attention has been paid of late years to the question of explanatory labels for the exhibition cases, and among those who have given special thought to this important subject is Dr. F. A. Bather, M.A., F.G.S., the Assistant Keeper of Geology. The subjoined is a specimen of a recently printed label prepared by him for the Echinoderm case, which serves to show how much information may be imparted to the student of geology and to the public at large by this means.

"*How Sea-Urchins are turned into Flint.*

Silica, the substance of which flints are made, is scattered through the Chalk formation in very minute particles, which are dissolved to some extent by water, especially if it be slightly alkaline. Consequently, as rain-water sinks into the Chalk it dissolves the silica and carries it with it through the Chalk. When the sea-urchins died and were buried in the chalky ooze, the inside of their shell or test was sometimes filled with the ooze, but sometimes it remained empty. In the latter case, when the Chalk became hardened and raised out of the sea, a cavity was left, into which flowed the dissolved silica. It may have been deposited on the walls of this cavity (i.e. the inside of the urchin's test) as

minute crystals of quartz (rock-crystal); or, as was more usually the case, it filled the cavity with a formless mass of the impure chalcedony that we call flint. So was fashioned in silica a cast of the inside of the sea-urchin test; and later on, as the Chalk was worn away by rain and rivers, and as its fossils thus came out on the surface, then the relatively soft and soluble test was worn or dissolved off. Therefore it is that many of these flint casts turn up on the surface of the downs or in gravel-pits. In some cases, however, the test itself became impregnated with silica: for the limy substance, of which the test is made, is very porous. The pores usually are filled in fossil specimens with crystalline carbonate of lime; but sometimes the silica got in first. When the flint was once deposited in this way, so long as it remained in the Chalk there was a tendency for further flint to be deposited round it, and so the sea-urchins are occasionally found embedded in masses of flint. Sometimes one finds only this surrounding flint with the impression of the outer surface of the urchin."

REVIEWS.

I.—The Atoll of Funafuti. Borings into a Coral Reef and the Results. Being the Report of the Coral Reef Committee of the Royal Society. 4to; pp. xiv and 428, with 6 plates at end of text and folding chart of soundings, 69 cuts in text, also with 19 plates in a separate portfolio. (Published by the Royal Society, 1904.)

THE much-discussed question as to the origin of Atolls has, of late years, been left a moot point, because the adherents to this theory or to that have recognised that no satisfactory conclusion can be come to without much further evidence, particularly that which would probably be supplied by a deep boring into an atoll. Such an undertaking, advocated by Charles Darwin, who first made the question of the origin of atolls notorious, has at last been accomplished by expeditions during three consecutive years, sent out under the control and at the expense of the Royal Society and the Government of New South Wales, and aided by private donations.

The Report of the Coral Reef Committee of the Royal Society on these expeditions occupies the pages of the volume under consideration. It has been edited by Professor T. G. Bonney, D.Sc., F.R.S., who became responsible for passing the volume through the press, and was also Chairman of the Coral Reef Committee. In the preface he gives a brief history of the various stages of the enterprise from its inception in 1893 to its completion. Its primary object, as defined in the instructions to its first leader, Prof. Sollas, was to investigate, by means of a boring, the depth and structure of a coral-reef, and all other work undertaken in furtherance of natural knowledge was to be considered as secondary to this object, whilst

with regard to the publication of the results, the Council of the Royal Society authorised the preparation of a monograph of which the main feature should be a description of the whole core from the points of view of the naturalist and the chemist. The cores and loose material were brought to London for detailed examination, and subsequently the half-cylinders of core and duplicate portions of the loose material have been returned to Sydney, and the part retained in England has been placed in the British Museum (Natural History) at Cromwell Road, South Kensington.

Professor Bonney further states, "that into the controversies about the development of coral-reefs, those who have been concerned in the preparation of this volume have not attempted to enter. They have endeavoured to state facts, and leave it to readers to interpret these for themselves. . . . . At any rate the composition, zoological and chemical, of an atoll down to a depth of 1,114 feet has now, for the first time, been made known." The final success of the undertaking is attributed by Professor Bonney to the zeal, energy, and liberality of friends in New South Wales, more especially of Professors Edgeworth David and Anderson Stuart, and of the Government of that Colony.

The Report is divided into fourteen sections, in which each author gives an account of the observations in his own branch of the work and of the results obtained, and in many cases inferences from these results are drawn. It is, however, desirable to bear in mind that these inferences represent the views of the individual authors of the respective sections, as in some instances they appear to be rather speculative.

The narrative, by Professor W. J. Sollas, D.Sc., F.R.S., of the first expedition, sent out under him in 1896, occupies the first section. The expedition was of little importance, except as paving the way for those that followed, and enabling them to succeed through the knowledge gained by its failures. For a failure it was as far as its main object was concerned; although two borings were attempted the first reached a depth of only 105 feet, and the second 72. They failed mainly through the inability of the machinery to deal with alternations of hard cavernous rock and loose sand.

To quote Prof. Sollas:—"Although the boring proved a failure, several other objects of the expedition were attained with complete success. Messrs. Hedley and Gardiner made a thorough investigation of the flora and fauna, both land and marine. Dr. Collingwood obtained a good deal of information of ethnological interest, and we all made a fairly complete collection of native implements and manufactures. A daily record was kept of maximum and minimum temperatures, and of the readings of dry and wet bulb thermometers. . . . The most important contribution, however, is afforded by the investigations of Captain Field, who made a complete topographical survey of the Atoll, and a vast number of soundings both in the lagoon and the outer sea; he also carried out magnetic and tidal observations."

A general description of the atoll is given, of its submarine slopes and of its surface features. The latter present six zones from the ocean to the lagoon, namely: (1) the Nullipore Rim; (2) the reef-flat; (3) the glacis of coral rock; (4) the Hurricane Beach; (5) the central flat of the islet; (6) the lagoon mound.

The features of the glacis of coral rock, especially its isolated outliers, are discussed, and also the mode of growth and the horizon of *Heliopora* and *Porites* now growing in the lagoon, as bearing on the former condition of the island; and the conclusion is arrived at that the island has undergone oscillations of level, which may possibly be correlated with a preglacial, glacial, genial, and present-day period in geological time.

Section ii, by H. C. Russell, C.M.G., F.R.S., gives an account of the meteorological observations made during the stay of Professor Sollas on the island; and section iii, by Captain E. W. Creak, R.N., F.R.S., is the report on the results of the Magnetic Survey of the atoll made by the officers of H.M.S. "Penguin," the ship which conveyed the expedition under Professor Sollas to Funafuti.

Section iv is the narrative, by Professor T. W. Edgeworth David, B.A., F.R.S., of the second and third expeditions made during the years 1897 and 1898.

After the failure of the expedition in 1896, Professor David, of Sydney, incited those interested in New South Wales to make a further effort to bore Funafuti, with improved boring-plant. By means of generous gifts of £650 from Miss Eadith Walker, of Sydney, and £100 from Mr. Ralph Abercromby, together with the loan of a diamond drill from the New South Wales Government, it was possible to send out a second expedition in 1897. A main bore was started, and, while this work was proceeding, an attempt was made to bore the floor of the lagoon. This lagoon boring proved a failure, and the raft on which the plant was erected was wrecked during a gale. Meanwhile the main bore proceeded slowly, and when it became necessary to return a depth of 698 feet had been reached.

In addition to the boring a geological survey was made of the various islets of the atoll, and a collection formed of various organisms living on the seaward slope of the atoll from depths of between 20 and 200 fathoms.

In the next year, 1898, "it was considered very desirable that an attempt should be made to deepen the main bore, and accordingly the Government of New South Wales and the Royal Society of London were approached on this subject. They both generously responded," and a third expedition was sent out under the leadership of Mr. A. E. Finckh. The Admiralty detailed H.M.S. "Porpoise," Captain F. C. D. Sturdee, for the work of again attempting a boring through the lagoon floor. This was accomplished successfully by Mr. G. H. Halligan, who sank two bores, one reaching 144 feet and the other 113 feet below the floor of the lagoon. The main bore, started during the previous year, was reopened, and a depth of 1,114 feet was attained. In addition to these results, permanent marks were left on the island by Mr. Halligan.

Section v, written by Professor David and Mr. G. Sweet, F.G.S., deals with the geology of the Funafuti atoll. Describing first its shape as a whole, they suggest that its elongation in a meridional direction is due rather to its being situated in a volcanic zone or fold-ridge, than to any influence of prevalent winds and ocean currents. The prevalent winds are the north-west monsoons and the south-east trades, the former being the stronger, and the storms caused by both result in the formation of the hurricane beaches of the islets.

The islets, as shown on the maps and sections accompanying the volume, may be divided into zones as already stated. A glance at the maps, however, shows a much more detailed division of the surface of the land than was given by Professor Sollas. It is to be regretted that Professor Sollas' divisions and those of Professor David are not compared, for in casually reading the account of one and then of the other the correlation is not obvious. However, the order from the ocean to the lagoon, and the correlation with the divisions of Professor Sollas, seem to be as follows. The symbols on the maps are given in brackets.

1. The outermost rim of living *Lithothamnion* (O.L. 10) = the Nullipore Rim of Sollas.
2. Zone of dead *Lithothamnion* (O. 3) = the reef-flat of Sollas.
3. Old reef of *Heliopora* and *Porites* (O.L. 1) } = glacis of coral rock
4. Breccia which overlies 3 (O. 2 B., O. 2 C., O. 2 D.) } of Sollas.
5. Hurricane beach (O. 1) = hurricane beach of Sollas.
6. Old reef of *Heliopora* and *Porites* and breccia, together with various newer and older superficial deposits (L. 6, L. 7, etc.) } = central flat of islet of Sollas.
7. Inner hurricane beach (O. 4), not always present.
8. Various superficial deposits of lagoon beach (L. 8, L. 9). } Not mentioned by Sollas.
9. Old reef of *Heliopora* and *Porites* and breccia, cropping out on lagoon side.
10. Zone of living *Lithothamnion*, present in channels leading into the lagoon, and in some places on the lagoon side of the islets.

The reef of *Heliopora* and *Porites* is the oldest rock which crops out on the island, and is in most places covered by the breccia. All the other deposits are superficial, and lie irregularly on these, which thus form the primitive reef-platform.

The sequence of events, which is not very clearly stated, seems to have been as follows:—First the *Heliopora* and *Porites* reef was formed, and then there was an uplift of from six to ten feet, during which time the breccia was formed by the marine denudation of the reef. The land then sank about 8 feet, and the breccia became cemented by *Lithothamnion*. Then another elevation occurred, allowing the breccia to come under the action of the waves which made breaches in the breccia barrier; and so the several islets were formed, and subsequently the Hurricane banks were piled up from the material of the breccia. Minor oscillations of level occurred, the present subaerial deposits were laid down, and the present fauna was introduced; a deposit of silt killed the *Heliopora* near the lagoon shore. Finally, there was an upward movement of 6 or

7 inches which killed the *Lithothamnion*, then living in the zone now marked as 'dead' *Lithothamnion* (O. 3). At the same time the Hurricane beaches were pushed further back.

In the future, probably, the lagoon will be filled up by the growth of *Halimeda*, and the islets will be gradually levelled by marine denudation. Against this destruction may be set a present upward movement of the land, as well as a very slowly widening rim of *Lithothamnion*. But another levelling factor is the subaerial denudation caused by the torrential tropical rains.

The biology of the reef-forming organisms, by Alfred E. Finckh, forms the subject of the next section.

Three main marine biological zones are noted, namely: (*a*) that of living *Lithothamnion*; (*b*) a zone of less active growth between the former zone and that line which marks the limit of the waves at low-water spring-tides; (*c*) the lagoon in which occur all forms found outside and in addition *Heliopora cærulea*. The bottom of the lagoon is formed mainly of *Halimeda* sand.

The organisms of the reef now forming, in the order of their importance, are as follows: (*a*) *Lithothamnion*, (*b*) *Halimeda*, (*c*) Foraminifera, (*d*) Corals and Hydrocorallines. *Lithothamnion* occurs in three forms, two encrusting and one frondose. *Halimeda* is the most important organism in the lagoon. The chief use of the corals and hydrocorallines in reef-building is to form a base-work on which *Lithothamnion* can grow. There are five main groups of corals and hydrocorallines occurring as follows in order of importance in reef-building: (*a*) *Heliopora cærulea*, (*b*) the Millepores, (*c*) the *Porites* family, (*d*) *Madrepora*, (*e*) *Pocillopora*.

Mention is made in this section of the enemies of the reef-formers. Excluding *Lithothamnion*, which, by its cementing action, constructs the reef more than it destroys it by its swamping effects on the other reef-forming organisms, the chief enemies are two Gephyrean worms, one of which is a Sipunculoid (*Aspidosiphon*). Holothuroids, supposed by Darwin to be destructive to the reef-formers, are acquitted of this charge, for it was found that their food was entirely composed of microscopic organisms.

A series of experiments are next described, carried out to ascertain, if possible, the rate of growth of the reef-forming organisms. The lack of experience in such experiments, their novel character, and the consequent absence of suitable apparatus caused the results to be somewhat vague. The situation of the camp precluded experiments upon the branching form of *Lithothamnion* and upon *Heliopora*. Four methods were employed, namely, weighing at intervals, measuring at intervals areas marked out on the coral by glass pins, measuring the distance of approaching portions of a coral and noting how long they took to meet, and causing the organism to grow through a hole in a board. Many of these specimens are now exhibited in the Geological Department of the British Museum, South Kensington. Experiments were also made on the amount of exposure to the sun needed to kill the various reef-formers. Less than two hours sufficed in the case of all except *Porites*.

Section vii is a short report of the dredging at Funafuti, by Professor David, G. H. Halligan, and E. A. Finckh.

In the lagoon seventeen out of eighteen dredgings were composed of detrital *Halimeda* and fragments of shells intermixed with a little seaweed. In the ocean living *Halimeda* only occurred down to 45 fathoms, the limit of penetration of red and yellow light. No pieces of an ancient coral-reef were dredged.

The branching form of *Lithothamnion* was found only to occur in shallow water. Thus it was thought that its presence in the cores might be of use in determining the depth at which any particular piece was formed. However, Dr. Hinde is of opinion that the exact form of *Lithothamnion* in the cores cannot be satisfactorily determined, that is, whether the branching, nodose, and incrusting forms correspond with the similar growth-forms from the reef-slopes.

Section viii is a report on the lagoon borings by G. H. Halligan.

Two borings were made at spots in the floor of the lagoon where the depth at low water spring tides was 101 feet. The first passed through 81½ feet mostly of *Halimeda* débris, next through 18 inches of hard coral, 33 feet of coral fragments, 18 inches of coral, and, finally, again through 26½ feet of coral material, thus in all 144 feet beneath the floor of the lagoon, or 245 feet below the sea-level. The second boring, a short distance from the first, went through 91½ feet of *Halimeda* débris, next through 3 feet of hard coral with intermediate bands of softer material, and then entered coral gravel and sand, to a depth altogether beneath the lagoon floor of 94½ feet, or 196 feet below the sea-level. Mr. Halligan finishes his report with the following words:—"It is perhaps only fair to mention that the lagoon borings here described were undertaken without the least idea of the formation to be expected, and were carried out under the most unfavourable circumstances possible. . . . . Had it not been for the co-operation and energy of the captain, officers, and men of H.M.S. 'Porpoise,' the work could not have been carried out at all."

Section ix, by the same author as the last, describes the permanent marks left by him on the island of Funafuti, to register for future reference the present levels of different spots. These marks were made of iron pipes let into the coral rock.

Section x is the general report by Professor J. W. Judd, C.B., LL.D., F.R.S., on the materials sent from Funafuti and the methods of dealing with them. The cylindrical cores and fragments of solid rock from the different borings were, on their arrival in London, slit longitudinally, and from those in the main boring to a depth of about 800 feet from the surface a thin slab of the whole size of each core was cut out of its middle. This slicing proved a very arduous task, particularly in the nearly continuous solid cores of the lower 400 feet of the boring, but it was very effectively done by means of a lapidary's wheel driven by an electro-motor. The slit surfaces of the hard cores when thus treated were sufficiently well polished to allow of the determination of the larger organisms

by means of a lens, whilst for the examination of the minute forms and of the mineral characters of the rock, more than 500 microscopic sections were prepared.

In addition to the materials from the borings, large collections of the existing fauna and flora of the atoll were made by Mr. Stanley Gardiner and Mr. Hedley, and Professor David and Mr. G. Sweet made strenuous efforts, at no small personal risk, to dredge up the organisms existing on the steep ocean slopes of the present reef to a depth of 200 fathoms. As a description of the existing organisms of the atoll was not included in the scope of the undertaking, the collections made have been, in part, studied by different specialists in this country and in Australia, and the results published in various scientific journals. A list of these memoirs is given by Professor Judd.

Section xi, by Dr. G. J. Hinde, F.R.S., contains the report on the materials from the borings at the Funafuti Atoll.

The main achievement of the later expeditions to Funafuti, under the direction of Professor David and Messrs. Finckh and Sweet, was the penetration of the reef at the main boring to a depth of 1,114 feet and obtaining materials which showed distinctly the nature of the rock to this depth. These materials were subjected to very careful scrutiny, and a detailed record of the various organisms recognized in each separate portion of the cores and their general mineral condition is given in this section of the Report. The nature of the material varied greatly in different parts of the boring. To the depth of 748 feet from the surface the greater part of the rock seems to have been of a friable and incoherent character, which in the process of boring was reduced to fine granular particles usually called sand, whilst the aggregate length of the solid portions of the core only reached 73 feet, or about one-tenth of the distance passed through. On the other hand, the lower third of the boring from 748 feet to the bottom at 1,114 feet was to a very large extent solid rock, forming a nearly continuous cylindrical core 311 feet in length. The friable upper portion down to 637 feet was mainly of calcium carbonate, whilst the lower solid third of the core was of dolomitic limestone.

No true oolitic grains were met with in any part of the cores, nor was any pumice or other volcanic material recognized. The presence of silica was not detected, though siliceous boring sponges were originally very numerous. Lines of stratification were not distinguished in the cores.

The rock throughout was entirely organic, derived from the calcareous skeletons of marine invertebrate animals and calcareous algæ; the principal rock-formers belong to Foraminifera, Corals, and Algæ, and with these are associated detached spines and test-plates of echinoderms, annelid tubes, crustacean tests, spicules of calcisponges and tunicates, and the shells or casts of lamellibranchs and gasteropods. The only vertebrate remains found in the cores was a single fragment of fish-bone or spine less than an inch in length.

Of the Foraminifera 35 genera are represented in the main boring;

they are equally as abundant in the cores and loose materials throughout the boring as in the beds at the surface of the reef now forming. The most important rock-forming genera in the order of their relative abundance are *Amphistegina*, *Polytrema*, *Orbitolites*, *Heterostegina*, *Carpenteria*, *Gypsina*, and *Calcarina*. All the forms belong to genera still existing, and no examples of characteristic Tertiary species were recognized. For the determination of critical forms the author acknowledges the invaluable assistance of Mr. F. Chapman.

Corals, including Alcyonaria and Hydrocorallinæ as well as the Madreporaria in this term, are present throughout the main boring, but, especially in the lower 350 feet, they are more numerous and varied than in the upper part. They have suffered greater changes in fossilization than any other group of organisms, and below a depth of 180 feet in the boring their walls and other structures have been for the most part dissolved and removed, and only casts in sedimentary or crystalline materials remain. In many instances they appear to be in the position of growth. Twenty-eight genera have been recorded from the borings; 22 of these are living at the present time on the reefs or in the lagoon at Funafuti. The commoner genera such as *Millepora*, *Lobophytum*, *Stylophora*, *Pocillopora*, *Astræa*, *Orbicella*, *Fungia*, *Madrepora*, *Astræopora*, *Montipora*, and *Porites* range from the top to the bottom of the main boring, but not continuously, for a particular form which has flourished through a series of consecutive cores will often disappear for a variable interval and then come in again. All the forms met with are reef corals; no examples of deep-water forms have been recognized in any of the cores.

Of the calcareous Algæ the most important genus, *Lithothamnion*, is represented by branching nodular, and, more especially, by encrusting forms which grow over corals and other organisms so as to bind them fast together and form layers of very compact dense rock. Another genus, *Halimeda*, is widely distributed throughout the cores; in some parts of the main boring and in the boring beneath the floor of the lagoon the rock is mainly composed of their detached segments.

Though the main boring reached to a depth of 1,114 feet it did not penetrate through the reef-rock, and the cores from the bottom were as distinctly reef-like as those from any other part of the boring.

The last three sections, dealing with the chemical and mineralogical composition of the cores, are of great interest.

First, Professor Judd describes the chemical aspect of the cores as shown in numerous analyses made by his assistants, Dr. C. G. Cullis and Dr. E. W. Skeats, and by Mr. Hart Smith, and this may be generally stated as follows. As far as 637 feet from the surface the core consists of calcium carbonate with a small proportion of magnesium carbonate. Below 637 feet the proportion of magnesium carbonate rises fairly suddenly to nearly 40 per cent. of the whole. Calcium phosphate is present throughout in minute quantities.

Volcanic rock is entirely absent. The proportion of magnesium carbonate between the depths of 10 and 20 feet rises considerably, and then falls away again. Professor Judd shows that under certain conditions calcium carbonate is more soluble than magnesium carbonate, and he thinks that "down to 637 feet the degree of enrichment of the rock by magnesium carbonate may be probably ascribed to the *leaching out* of calcium carbonate," and this accounts for the friability of the upper part of the core.

The presence of the large percentage of magnesium carbonate in the lower part of the boring is considered by Professor Judd to be due to some such segregation as has produced flints in the Chalk, and the iron disulphide nodules of other formations. The material of a reef "is everywhere permeated and acted upon by sea-water, containing a very notable proportion of magnesium, principally in the condition of chlorides and sulphates. May not these materials, enriched by the magnesium carbonate, exercise an attractive action on the magnesium salts of the ocean waters, giving rise to double decomposition and the gradual replacement of a part of the calcium in the carbonates by magnesium?"

Section xiii consists of some remarks by H. C. Sorby, LL.D., F.R.S., concerning the production of aragonite and dolomite in the coral rock. Dr. Sorby thinks that there "may be special conditions not fully understood under which carbonate of lime may crystallise as aragonite at such a temperature as would be met with in coral rock." Obviously this must be so, for Dr. Cullis has found secondary aragonite in the cores. Dr. Sorby was not able by artificial means to replace calcium carbonate by dolomite; he only succeeded in replacing it by magnesium carbonate.

The last section is the account, by C. Gilbert Cullis, D.Sc., F.G.S., of the mineralogical changes observed in the Funafuti borings. Near the surface the cores consist of calcite and aragonite according to the composition of the skeletons of the organisms of which it is made. The magnesium carbonate and other chemicals present in the cores are not perceptible in a microscope-section as crystals.

The first change that occurs as a greater depth is reached is that the cavities in the organisms composing the cores become filled with secondary calcite and aragonite. Next the secondary aragonite becomes converted into calcite, and finally the primary aragonite also becomes similarly converted. Thus at 220 feet the cores consist entirely of calcite. From 637 feet dolomite begins to replace the calcite, and from 650 to 820 feet pure dolomite is present. From 820 to 875 feet, and again from 1,050 to 1,070 feet, calcite is again present with the dolomite. Apart from this the core from 650 to 1,114 feet, the lowest point reached, is of pure dolomite.

This section is excellently illustrated with figures of microscope-slides of sections from different depths, and also by diagrams illustrating the mineralogical changes.

The volume is illustrated by six plates, a number of woodcuts, and charts of the atoll. Accompanying it is a portfolio with geological maps and sections of the islands. Printed in large, clear

type, and finishing with a good index, it has all the requirements of a book of reference.

The evidence of the borings shows that, in the case of Funafuti, with small temporary oscillations of level, there must have been a steady downward movement for a very long time to account for 1,100 feet of coral rock of comparatively recent accumulation. Another noticeable conclusion is that, at any rate in the case of this 'coral island,' corals are not the most important reef-formers.

It is a matter for regret that the Royal Society should be unable to afford a larger sum for carrying out an undertaking of the importance of that described. The expeditions in consequence had to depend largely on private donations and individual help, and without these the second expedition would never have been started. On the other hand, all scientific men will read with pleasure how willingly assistance of all kinds was rendered by those private persons with whom the expedition came in contact.

W. D. L.

II.—Dr. A. W. Rowe on the Zones of the White Chalk of Yorkshire. (Proc. Geol. Assoc., vol. xviii, pt. 4; 104 pp., 24 plates and 2 text-figures.) (London: E. Stanford, 1904. Price 3*s*.)

In this breezy record of his work in Yorkshire Dr. Rowe has compounded a bracing tonic for all geologists, and especially for those whose appreciative faculties may have become so impaired by the undigested load of accumulated facts that they have lost that keen relish for discovery which should be the never-failing reward of the investigator. We are made to feel as we read this paper that to its author every fresh discovery still comes, as it should come, with the force of a revelation, and is honoured as such. Surely, whoever reads that exciting dramatic episode—so well told and withal so refreshing in technical literature—of the finding of the prognosticated *Micraster* after a venturesome voyage to a well-nigh inaccessible part of the coast must realize that there are moments when it is indeed good to be a geologist! The importance of our discoveries in science, where not directly 'practical,' depends mainly upon the force with which they appeal to our imagination, and herein lies the strength of Dr. Rowe's method. His naive surprise when the new knowledge happens to burst the bounds of his previous experience, and his satisfaction when it happens to conform to that experience, are admirably expressed and equally delightful. The whole process by which dead facts become vital thoughts is exemplified as Dr. Rowe picks up shred after shred of evidence and pieces it into his fabric. We are forcibly reminded of Browning's fine description of the scientific method—

> "Up and down, inch by inch, with the taper his reason
> No torch, it suffices—held deftly and straight.
> Eyes purblind at first, feel their way in due season."

The author knows that he is doing work worth doing and is doing it well, and he is happy in doing it. No wonder, then, that geologists

and palæontologists alike have watched his progress with admiration and with critical interest! The results which he has already achieved are of far-reaching importance, and the paper before us shows that he has not yet reached the zenith of his powers.

The zonal correlation of the Yorkshire Chalk with the Chalk of the South of England presents many difficulties, and in spite of the brave attempt made by Dr. C. Barrois over a quarter of a century ago, it has been long recognized by local workers that the problem was still unsolved. This problem Dr. Rowe has taken as his latest holiday task, and with the aid of his trusty coadjutor, Mr. C. D. Sherborn, has shown that by proper methods even the sturdily resistant mass of Flamborough Head may be sliced up into zones more or less closely equivalent to those of the south, with well-nigh the same ease as the less obdurate cliffs that overlook the Channel.

On taking his giant-stride northward, however, Dr. Rowe has found himself confronted by many conditions that were new to him and by many problems that for the present he is content to waive. He has wisely concentrated his forces upon the establishment of the broad correlation, and has regarded other matters as side-issues to be dealt with when the opportunity occurs.

The keynote of his attitude is struck in the introduction to his paper and is well sustained throughout. "We have long cherished a furtive ambition," he writes, "to explore this mysterious and legendary coast." And again, "There is a glamour and fascination attached to the unknown, which, coupled with the acknowledged difficulties of a coast like this, greatly adds to the zest of the work. For this coast is unknown. It is a veritable *terra incognita*."

Now, this last sentence will seem a hard saying to the assiduous local investigators to whom Dr. Rowe warmly expresses his indebtedness; and even to anyone knowing only the previously published literature it may appear high-pitched. But the author justifies his statement in the context, by explaining that the only kind of information which he himself desired was not available until he had explored the land. After all, he has only taken the customary privilege of the explorer of new regions, with whom the uncoordinated local knowledge of the aborigines does not count. And in similar manner it may happen in the future that Kent itself will prove a *terra incognita* to a worker carrying some special line of investigation southward from the Northern Chalk, for it is certain that there is still an open field for research in every part of the formation.

Dr. Rowe's Yorkshire work is of peculiar interest inasmuch as it reveals not only the strength but also the weakness of the zonal method of correlation when applied to districts lying apart. We find that again and again is the author startled by the strangeness of his northern experiences, until at last he is constrained to declare—"The record of the fauna in this area constitutes a veritable zoological romance. Verily it is a land of strange zonal occurrences and of still more strange zonal omissions. It is, indeed, the remarkable

absence of some of the commonest zonal fossils, together with the unreliability of others which do exist, which has rendered the task of zoning this Chalk so difficult, but, withal, so fascinating." That is how the scanty ill-preserved fauna of the Yorkshire Chalk appeals to one who has the art to read its lesson!

Now, the meaning underlying this and other similar sentences evidently is that Dr. Rowe, having been able to define the range of most of the Chalk fossils in the cliff-sections of the South of England within fixed limits, and having found them persistent within these limits in that region, had begun to have faith in these zonal boundaries as representing the full life-history of the species. But his journey northward has impressed upon him that the range of many of his zonal species is not everywhere the same. It is true that he has still managed skilfully to extract sufficient evidence to re-establish Barrois' system of correlation on a firmer basis, and to prove, what was indeed already acknowledged, that the general zonal succession in Yorkshire corresponds to that in the South of England. In studying the range of the individual species, however, and their grouping, he finds that some cherished guides have wandered far from the path of zonal rectitude. Thus we read—"The vertical range of certain fossils, usually restricted in their distribution, is so vast that their very persistence is bewildering. As instances of this contention we may quote a range of 800 feet for *Actinocamax granulatus*, and 650 feet for *Actinocamax verus*; while *Cardiaster ananchytis* has been traced for 640 feet, and *Infulaster rostratus* for nearly 700 feet."

"That *Actinocamax verus* should be found in the *quadratus*-chalk; that *Actinocamax granulatus* should be found some 350 feet up in the same zone; that *Infulaster rostratus* should range from the zone of *Micraster cor-testudinarium* to that of *Actinocamax quadratus*; and that *Cardiaster ananchytis* should extend from the *Micraster cor-anguinum*-zone to the same horizon, are facts sufficiently unusual to warrant special comment."

Therefore, although Dr. Rowe and Mr. Sherborn have been able to prove the presence in the Flamborough cliffs of all the zones from that of *Rhynchonella Cuvieri* to that of *Actinocamax quadratus*, inclusive, it is acknowledged that for some of these zones the guide-fossils on which they had been accustomed to rely are inadequate in this district for the identification of the divisions.

To meet this difficulty Dr. Rowe suggests, though with evident reluctance (p. 219), that in certain cases the name of some other fossil, locally abundant, should be associated with the established name-fossil as its "local equivalent." We commend the wisdom of this course, for however much it may be desirable to adhere to established zonal nomenclature for purposes of wide-reaching correlation, it is unnecessarily perplexing to the student and irritating to the stratigrapher to find that a particular zone is marked by the *absence* of its name-fossil!

Hence the choice of the characteristic *Inoceramus lingua* as the local guide for the zone of *Actinocamax quadratus*, since the last-

named form appears not yet to have been found at all in Yorkshire, will meet with the approval of every local worker.

The choice of *Infulaster rostratus* to serve a similar purpose for the zone of *Micraster cor-anguinum* is, however, open to question, although when first suggested it seemed to the present writer to be well adapted. But its range has been so greatly extended by Dr. Rowe's researches, both above and below the belt in which it is most abundant, and with which its name is now associated, that its unsupported presence seems inadequate to determine the zone, and we should feel less confident than the author in assigning a small inland pit "without hesitation" to the zone of *Micraster cor-anguinum* on the strength of the discovery of this fossil alone (p. 233).

And here we may note that in respect to Dr. Rowe's demarcation of the zone of *Micraster cor-anguinum* there appears to be a certain arbitrariness, perhaps unavoidable but still unsatisfactory, especially since the zone as now defined is made to bestride the only lithological line traceable in the Yorkshire Chalk, namely, that separating the flinty from the flintless Chalk. Indeed, with regard to several of the zonal boundaries Dr. Rowe will no doubt himself be ready to allow that in these Yorkshire sections, when the evidence is often so imperfect, the chosen line reflects in its particular location an opinion or deduction rather than an absolute fact, even though it represent the best conventional line that is likely to be attained. The position is precisely that in which the mere stratigrapher often finds himself in tracing boundaries that he knows to lie within certain limits but to be indeterminable within these limits. And just as the stratigrapher's line when drawn on the map sometimes gives an unwarranted impression of finality, so may these zonal boundaries if too rigidly interpreted.

One important deduction to be drawn, then, from Dr. Rowe's experiences in the Yorkshire Chalk — a deduction that has also impressed itself upon the present writer in extending the area of his investigations in the Lower Cretaceous rocks—is that, although the general succession of life-forms that go to the making of 'zones' remains constant over wide areas, the range and association of individual species, however sharply defined at one spot, can rarely be traced far without showing disintegration and change. Thus the difficulties that beset the stratigrapher owing to gradual change in the lithological character of sediments have their counterpart in the difficulties that beset the zonal palæontologist in the gradual change of zoological assemblages.

The diversity between the fauna of the southern and northern Chalk has long been recognized, but it has never before been so definitely formulated as by Dr. Rowe, and we regard this detailed comparison as the most valuable part of his paper. For the present he is content to state the differences without attempting further to discuss the cause than to state (p. 280) that they afford "convincing evidence of the working of variation in geographical distribution." It is indeed astonishing that in such a continuous and homogeneous mass as the Chalk, which seems to postulate that the physical conditions of the sea-floor must have been well-nigh identical over the whole region covered by the deposit, there should be this great

difference between the fauna of corresponding horizons in Yorkshire and in Kent. It is true that in the Lower Cretaceous the difference between the two areas is even more conspicuous, but in this case we are dealing with beds of diverse lithological composition, and with complex geographical conditions that are sufficient to explain the anomalies.

What is the meaning of this extraordinary diversity within the same geographical province? We can scarcely believe that climatic variation due to the trifling difference in latitude could make itself directly felt at the bottom of the comparatively deep Upper Cretaceous sea. Can it have been due to the influence of cold-water currents creeping down from the north? Or may we surmise that some of the life-forms themselves in spreading from separate centres of dispersal have exerted a mutually antagonistic effect upon each other, so that they could not pass freely beyond their respective frontiers? Or is it, after all, only that ever-present mischief-maker, 'the imperfection of the geological record,' that is to blame for our difficulties?

We hope that at some future time Dr. Rowe will deal more fully with this fascinating problem, for assuredly he is peculiarly well qualified for the task. And in doing so we shall expect that he will give us that comparison of the Yorkshire fauna with the fauna of the equivalent beds in Germany which is referred to (p. 284), but at present withheld. This comparison is likely to be of singular interest, for apparently some portions of the Yorkshire Chalk have, like portions of the Speeton Clay, closer faunistic affinities with the equivalent rocks of Germany than with those of the South of England.

In laying stress upon this aspect of Dr. Rowe's results we must not omit to call attention also to the discoveries of the author which go to strengthen the correlation between the northern and southern Chalk. Thus, his recognition of the plentiful occurrence of *Uintacrinus* in Yorkshire in its customary position at the base of the *Marsupites*-zone is a notable bond in the correlation and an advance on our previous knowledge. Several other southern fossils not hitherto recorded from Yorkshire have now been identified and are included in the new list.

The value of the author's method from the stratigraphical point of view is strikingly exemplified by his discovery that the zone of *Rhynchonella Cuvieri* is absolutely crushed out for a space by the overthrust fault in the Buckton Cliffs. The character of the disturbance at this place had been previously recognized, but its effect upon the sequence was unknown until established by the palæontological evidence.

Another result given in this paper which the local geologists will be eager to apply in the field is the demonstration of a progressive deepening in the alveolar cavity of *Actinocamax granulatus* when this fossil is traced upward through the *quadratus*-zone. We congratulate Dr. Rowe on his acumen in seizing upon practically the only organism of the Yorkshire Chalk which is sufficiently abundant and well-preserved to allow its zonal variation to be worked out.

As the author expressly disclaims that his paper should be taken as more than "a preliminary attempt to bring the fauna of the Yorkshire coast into line with that of our southern sections," and as he has so successfully achieved this object, it would be both unjust and ungrateful to consider his work in any other light. Now that the way is made clear we shall expect that the group of persistent investigators dwelling in the East Riding will push forward the work with renewed energy, not only testing what has been done but also adding to it where necessary. Especially should we like to hear of the establishment of local zones of less extensive dimensions than those which Dr. Rowe has given us. The value of a narrow zone to the stratigrapher was strikingly manifest in the above-cited instance at the Buckton overthrust fault. Here the author had the advantage of having to deal with the only narrow zone in his category—that of *Rhynchonella Cuvieri*. The thickness of this zone in the Buckton cliffs is no more than 11 feet, whereas the next in dimensions, those of *Micraster cor-testudinarium* and *M. cor-anguinum*, are given as 120 feet and 125 feet: and all the others range between 200 and 300 or more feet. Moreover, even with such extensive bounds allotted to them some of the zonal forms are still not content, but manage to invade their neighbour's territory. Thus we learn that "*Holaster planus* is as common in Yorkshire in the zone of *Ter. gracilis* as at its own horizon." Faults of considerable magnitude may remain undetected in the interior unless we can find means to identify belts of strata of much narrower limits. Indeed, we are reminded by the coloured map which accompanies Dr. Rowe's paper of a long-standing suspicion that there is likely to be some disturbance of the normal succession at Speeton between the railway line and the coast, to which the pinching in of the zones in this quarter may be due; and the reviewer would recommend this area, with the country to the south and west, to further consideration.

The Cenomanian or 'Lower Chalk' in this as in his former papers does not come within the range of Dr. Rowe's investigation. We think, however, that it would have been well at least to include it in giving estimates of the total thickness of the White Chalk of Yorkshire, since in this region the division is essentially part of the lithological mass which we mean when we refer to the 'Yorkshire Chalk.' Moreover, this part of the series had previously been worked out with great care by Mr. W. Hill, so that accurate measurements were already available. It is true that passing reference is made to Mr. Hill's paper, but there would have been a distinct advantage if we had had a few sentences giving a summary of this work in the present publication, so that some account of the whole section might have been contained under one cover.

The lavish wealth of illustration to which Dr. Rowe has accustomed us in his previous works is again granted to us and deserves our gratitude. The magnificent series of photographic reproductions (in most cases from originals for which the author tenders his acknowledgments to Professor H. E. Armstrong) brings up vivid reminiscences of this noble coastline.

The sections, prepared by Mr. C. D. Sherborn, are effective, though somewhat crudely diagrammatic. We notice, however, that the displacement by the fault at Selwicks is not indicated. The coloured map already referred to, also prepared by Mr. Sherborn, is a useful guide to the probable range of the zones in the interior of the headland, though in drawing the boundaries it is probable that insufficient allowance has been made for the relief of the ground in view of the prevalent low dip. The Appendices to the paper include the description by Mr. G. C. Crick of a curious Belemnite, probably deformed by some injury to the living animal; and there is also a short note by the present writer on the state of preservation of some of the Chalk fossils.

In conclusion, let it be acknowledged that no adequate criticism of work of this kind could be made except by one whose knowledge of the subject transcended that of the author. And our only hope, therefore, of ever obtaining such a criticism is that Dr. Rowe may himself undertake it some time in the future, when he has completed his examination of the separate districts and reviews his previous work as a whole. G. W. Lamplugh.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

March 23rd, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communication was read:—

"On the Moine Gneisses of the East Central Highlands and their Position in the Highland Sequence."[1] By George Barrow, Esq., F.G.S.

The paper is divided into two parts. The first deals with the parallel banded grey gneisses or gneissose flagstones of the Perthshire and Aberdeenshire districts, which, in their field-characters as well as in their composition and structure, are identical with the Moine gneisses of the North-West Highlands. A description is given of these gneisses, as seen in and about the Garry in Perthshire, and this is followed by a brief account of the same rocks in the ground to the east and north-east, extending to the Forest of Invercauld, north of Braemar in Aberdeenshire. Special attention is drawn to the fact that towards the eastern end of the area large masses of highly quartzose gneiss occur, which are really part of the Central Highland quartzites in what the author conveniently describes as a 'Moine phase,' and should not strictly be included in the typical banded grey gneisses at all.

In the second part, dealing with the mode of ending off of these gneisses to the south-east, it is shown that they cease to be recognizable as Moine gneisses, owing to the fact that they thin away and also become more finely banded, while at the same time they become less crystalline or cease to be gneisses. To prove this, an account

[1] Communicated by permission of the Director of H.M. Geological Survey.

is given of a series of sections lying along a belt of 40 miles in length, extending nearly from Blair Atholl to the east of Balmoral, in Aberdeenshire. The first and most important of these occurs about Gilbert's Bridge (in Glen Tilt), where the parallel banded Moine gneisses can be traced passing slowly into the honestones, in which parallel banding is equally well shown. This is a well-known horizon in the Central Highland sequence, lying next the white edge of the Highland Quartzite, forming, in fact, its orginal flaggy margin. These parallel banded rocks are in many cases succeeded directly by a very impure phase of the Main or Blair Atholl Limestone; but in places patches of other material intervene, of which the most important is a dark schist: this suggests a small hiatus at the margin of the Limestone, and a photograph was exhibited to show this hiatus. The conclusions drawn from this section are supported by the section seen below Gilbert's Bridge, and a somewhat similar one in the Banvie Burn, north of Blair Castle. As before, there is clearly a small hiatus at the base of the Limestone.

In order to ascertain the meaning and extent of this break in the sequence, an account is next given of the complete succession near Braemar, and it is then seen that at Gilbert's Bridge the Little Limestone and part, or at times the whole, of the Dark Schist is missing. The hiatus always tends to occur as an area is approached where the material forming the Moine gneiss thickens, and was originally of a rather coarser or more sandy nature.

Where, however, the section is complete, it is seen that the material of the Moine gneisses is the flaggy margin or top of the Central Highland Quartzite; it is succeeded by the Little Limestone, above which is the Dark Schist, and then the Main or Blair Atholl Limestone.

Other sections along the line of change are described, showing the varying phases of the honestones, and in two instances their passage into Moine gneiss. There is a constantly varying hiatus at the base of the Main Limestone, but in the whole 40 miles this never exceeds the omission of the entirety of the Black Schist and the Little Limestone (of no great original thickness). This break in the sequence is of small importance, and, as already stated, often disappears as the material from which the Moine gneisses were formed became thinner and finer, or more of the nature of a mud.

Evidence is then given to show that the honestones tended to become more sandy and to thicken south-eastward again, or in the opposite direction to that in which the Moine gneisses come on. From this the author concludes that the parallel banded material was deposited in a series of fans; in the larger fans we have the material of the Moine gneisses; in the smaller that of the honestones. Both are simply the flaggy top of the sandstone now forming the Central Highland Quartzite, and are in fact a passage rock on its margin. Anything like an unconformity between the two is obviously impossible.

II.—Mineralogical Society, March 22.—Professor H. A. Miers, F.R.S., Vice-President, in the Chair. The following papers were read:—Irregularly developed crystals of zircon (specific gravity 4·0) from Ceylon: L. J. Spencer. The crystals were sent recently by Mr. A. K. Coomáraswámy to the British Museum for determination, and at first were thought to be rutile. They are of a dark-brown colour and almost opaque; the specific gravity is 4·09, and is unaltered by heating. A section cut perpendicular to the principal axis shows interesting variations in the optical characters, successive portions being isotropic, uniaxial, and biaxial; the mean refractive index is about 2·0. After being heated to redness and cooled, the material is bright-green in colour, and a crystal section is now entirely biaxial, although the interference figures and birefringence vary in different parts.—Notes on 'Feather Ore,' identity of 'domingite' (= 'warrenite') with jamesonite: L. J. Spencer. 'Feather-ore' is usually considered to be a variety of jamesonite; but, since the latter has a good cleavage perpendicular to the length of the fibres, only brittle 'feather-ore' can be included in this species; on the other hand, 'feather-ore' the fibres of which are flexible may be either stibnite, zinckenite, plumosite ($2\,PbS,\ Sb_2S_3$), boulangerite, or meneghinite. 'Warrenite' is a brittle 'feather-ore,' and further has the same chemical formula ($3\,PbS,\ 2\,Sb_2S_3$) as that originally given for the cleavable Cornish jamesonite.—Note on the indices of refraction of antimonite: A. Hutchinson. A prism of refracting angle 8° 51′ was found sufficiently transparent to red light for the refractive indices to be determined in the usual way. The results obtained are 4·129 and 3·873 for rays vibrating parallel to the axes of z and x respectively. Measurements of the deviation of the ultra-red rays indicate high dispersion in this region of the spectrum. The investigation is being continued. The connection between the atom arrangements of the crystals of certain allied carbon compounds: W. Barlow. Using balls of the same relative size as employed in his previous work, for instance in models of calcite, the author forms a carboxyl slab. By uniting such slabs with balls representing barium, a structure is obtained which has the symmetry of barium formate. Again, by uniting the slabs with balls representing hydrogen, a structure with the symmetry of oxalic acid is formed. The author showed that in certain cases, in order to effect close packing, a relative shift was necessary between successive layers. He also briefly discussed the tartaric acids.—On the construction and use of the moriogram: G. F. Herbert Smith. The moriogram is a diagram devised by the author for the graphical determination of the angles between tautozonal poles, obeying the law of rational indices.—Note relative to the history of the Caperr meteorite: L. Fletcher, F.R.S.—On the meteoric irons of Bethany, Lion River, Springbok River, and Great Fish River, South Africa: L. Fletcher, F.R.S.—Professor J. W. Judd, F.R.S., exhibited two Gardette twins of quartz.

CORRESPONDENCE.

BRIDLINGTON CRAG.

Sir,—The shelly patches in the Basement Boulder-clay at Bridlington, known as the "Bridlington Crag," have been so long inaccessible that it may interest glacial geologists to know that these beds are being temporarily exposed in the foundations for a new sea-wall. It is now twenty-one years ago since these shelly patches were last seen, in a brief exposure on the foreshore, and when the new wall is built they will be more hopelessly hidden than ever.

The excavations are carried on between tide-marks, in short lengths which are filled in at once. The section which I saw three weeks ago during a hasty visit to Bridlington showed about 5 feet of Boulder-clay with narrow streaks and dabs of richly glauconitic sand full of broken shells. I learn that, in other places, larger patches of the sand, with some unbroken shells, have been found, like the masses which I saw and described in 1882–3.

It is satisfactory to be able to add that the East Yorkshire geologists are alive to the opportunity, and are taking steps to secure material for the further study of this exceptionally interesting Arctic fauna.

G. W. Lamplugh.

Dublin.

OBITUARY.

LIEUT.-GENERAL CHARLES ALEXANDER McMAHON, F.R.S., F.G.S.

Born March 23, 1830. Died February 21, 1904.

We regret to record the loss of an excellent geologist and petrologist, and a prominent Fellow of the Geological Society of London.

The name of General McMahon suggests the thought of the number of Army officers who have taken up our science as a pursuit and achieved distinction, either in geology, palæontology, or in mineralogical geology, often without any early scientific training, as was the case with General McMahon. We recall the names of General Portlock, Sir Roderick Murchison, General Strachey, General Sir Proby T. Cautley, General Hardwicke, General F. T. Hobson, Colonel Godwin-Austen, Captain Hutton, Major Brickenden, Major Broom, Captain H. G. Lyons, Dr. Leith Adams, and many others. How great would be the list if our cadets at Woolwich, Sandhurst, and elsewhere were encouraged to work at such subjects by means of lectures, laboratories, museums, and field-work, proficiency to be rewarded by suitable marks in examinations!

Charles Alexander McMahon was born at Highgate 23rd March, 1830, and was the son of Captain Alexander McMahon, of the H.E.I.C. Service. He served for eight years in the 39th M.N.I., and for thirty years on the Punjab Commission. He was late Commissioner of Lahore and a Fellow of Lahore University.

Although, outside his official life, Lieut.-General C. A. McMahon was well known as an ardent and able geologist, his name is

remembered in India for the thirty years of excellent work as a Commissioner and Civil Judge. The most exciting period of his career was at the time of the Indian Mutiny, when, as a young man under thirty, he was suddenly called upon to assume charge of the Sialkot district, just at the moment (May, 1857) when the native troops rose in revolt. Lieutenant McMahon managed to send off a few lines to General John Nicholson, who was taking a movable column to Delhi. This prompt action led to the mutineers being met and destroyed by Nicholson at the action of Trimmos Ghat.

When Commissioner of Hissar, in 1871, General McMahon took up the study of geology and petrology; and when on furlough to England in 1879–80 he joined the Royal School of Mines, studying geology under Professor Judd, mineralogy under Sir Warington Smyth, and biology under Professor Huxley. Professor Judd writes:—"On his return to India he took up a series of geological studies of the granites and other rocks of the Himalayas, the result of his labours being given to the world in a number of papers published in the Records of the Geological Survey of India. After his retirement he continued these researches with the same enthusiasm as before, devoting special attention to petrological and mineralogical investigations. Even after the failure of his health, and when afflicted with almost complete blindness, he not only maintained an interest in his favourite pursuit, but dictated a paper which appeared quite recently in the GEOLOGICAL MAGAZINE."[1] He became a Fellow of the Geological Society in 1878, and received the Lyell Medal in 1899 "in recognition of the value of his services to petrology, and more particularly of the work done by him in India." He served on the Council, was a Vice-President of the Geological Society; and President of the Geological Section of the British Association at Belfast in 1902. He was elected President of the Geologists' Association in 1894–95. Dr. W. T. Blanford, a valued friend of General McMahon's, and for 30 years connected with the Geological Survey of India, says:—"In the exploration of the principal rock groups in the Western Himalayas he was a pioneer, and his discoveries were of great scientific importance. From 1877 to 1887 General McMahon contributed 24 papers to the Records of the Geological Survey of India, for the most part descriptive of the geology and petrology of districts in the Simla area, thence northward to Spiti, and around Dalhousie and Chamba, and in a few other localities. The so-called Himalayan Central Gneiss he showed to be an intrusive granitic formation." The death of General McMahon closes a strenuous life of recognized service to Government in his administrative career in India, and of fruitful scientific research in geology, a combination testifying to intellectual equipment unusually varied and to uncommon mental energy maintained until the very last.

General McMahon married, first, Elizabeth, daughter of Colonel C. F. Head, late Queen's Royal Regiment, and secondly, Charlotte

[1] November, 1903, p. 492.

Emily, daughter of Mr. Henry Dorling, of Stroud Green House, Croydon, who survives him. The distinguished Indian frontier political officer, Lieutenant-Colonel A. H. McMahon, C.S.I., C.I.E., F.R.G.S., F.G.S., Judicial Commissioner at Quetta, Beluchistan, is his eldest surviving son. (In part from *The Times*.)

LIST OF PAPERS BY LIEUT.-GENERAL C. A. McMAHON.

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"Notes on the Section from Dalhousie to Pangi, viâ the Sach Pass": India, Geol. Survey Records, xiv (1881), pp. 305–310.

"The Geology of Dalhousie, North-West Himalaya": India, Geol. Survey Records, xv (1882), pp. 34–51.

"On the Traps of Darang and Mandi in the North-West Himalayas": India, Geol. Survey Records, xv (1882), pp. 155–164.

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"On the Basalts of Bombay": India, Geol. Survey Records, xvi (1883), pp. 42–50.

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"On the Lavas of Aden": India, Geol. Survey Records, xvi (1883), pp. 145–158.

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"The Rape of the Chlorites": Geol. Mag., Dec. IV, Vol. I (1894), pp. 111–114.

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Appendix to W. H. Hudleston's paper on Indian Geology: Proc. Geol. Assoc., vol. xiv (1896), p. 292.

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"Notes on some Volcanic and other Rocks which occur near the Baluchistan-Afghan Frontier, between Chaman and Persia": Quart. Journ. Geol. Soc., vol. liii (1897), pp. 289–309.

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